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forêts

**Biogeochemistry of temperate forest
ecosystems : Literature on inventories
and dynamics of biomass and nutrients**

**Biochimie des écosystèmes des
forêts tempérées : publications sur
les inventaires et la dynamique
de la biomasse et des éléments nutritifs**

Rapport d'information

Information Report PI-X-47 E/F



BIOGEOCHEMISTRY OF TEMPERATE FOREST ECOSYSTEMS:
LITERATURE ON INVENTORIES AND DYNAMICS
OF BIOMASS AND NUTRIENTS

BIOCHIMIE DES ÉCOSYSTÈMES DES FORÊTS TEMPÉRÉES:
PUBLICATION SUR LES INVENTAIRES ET LA
DYNAMIQUE DE LA BIOMASSE ET DES ÉLÉMENTS NUTRITIFS

Information Report/Rapport d'information

PI-X-47E/F

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This report is based on ENFOR project P-197 which was carried out under contract (DSS File No. KL011-1-0021) by the Canadian Forestry Service and the University of British Columbia.

ENFOR is the acronym for the Canadian Government's Energy from the FOREst (Energie de la FORêt) program of research and development aimed at securing the knowledge and technical competence to facilitate, in the medium to long term, a greatly increased contribution from forest biomass to our nation's primary energy production. This program is part of a much larger federal government initiative to promote the development and use of renewable energy as a means of reducing dependence on petroleum and other non-renewable energy sources.

The Canadian Forestry Service (CFS) administers the ENFOR Biomass Production program component which deals with such forest-oriented subjects as inventory, harvesting technology, silviculture and environmental impacts. (The other component, Biomass Conversion, deals with the technology of converting biomass to energy or fuels, and is administered by the Renewable Energy Branch of the Department of Energy, Mines and Resources). Most Biomass Production projects, although developed by CFS scientists in the light of ENFOR program objectives, are carried out under contract by forestry consultants and research specialists. Contractors are selected in accordance with science procurement tendering procedures of the Department of Supply and Services. For further information on the ENFOR Biomass Production program, contact

ENFOR Secretariat
Canadian Forestry Service
Ottawa, Ontario
K1A 1G5

or a CFS research laboratory.

Le présent rapport a été rédigé suite à l'étude ENFOR P-197 qui a été réalisée à contrat (dossier MAP: KL011-1-0021) par le Service canadien des forêts et l'Université de la Colombie-Britannique.

ENFOR est l'acronyme employé pour désigner le programme de recherche et de développement ENERGIE de la FORêt (ENERgy from the FOREst) du gouvernement canadien dont l'objectif est d'acquérir des connaissances et des compétences techniques pour faciliter à moyen et à long terme un accroissement important de l'utilisation de la biomasse forestière pour la production d'énergie au pays. Ce programme fait partie d'une initiative beaucoup plus vaste du gouvernement fédéral en vue de favoriser l'exploitation et l'utilisation des formes d'énergie renouvelables de façon à réduire la dépendance vis-à-vis le pétrole et d'autres sources d'énergie non renouvelables.

Le Service canadien des forêts (SCF) est responsable de la partie du programme consacrée à la production de biomasse où l'on se penche sur des questions intéressant la forêt telles que les inventaires, les techniques de récolte, la sylviculture et les incidences environnementales. (L'autre partie du programme, intitulée "Transformation de la biomasse", porte sur les techniques de transformation de la biomasse en énergie ou en combustibles; elle est la responsabilité de la Direction des énergies renouvelables du ministère de l'Énergie, des Mines et des Ressources.) La plupart des études sur la production de la biomasse, même si elles ont été élaborées par des scientifiques du SCF compte tenu des objectifs du programme ENFOR, sont réalisées à contrat par des consultants en foresterie et des chercheurs spécialistes. Les contrats sont octroyés conformément aux méthodes suivies par le ministère des Approvisionnement et Services pour les marchés scientifiques. On peut obtenir plus d'informations sur le sous-programme de production de la biomasse en s'adressant à un laboratoire de recherche du SCF ou en écrivant à l'adresse suivante:

Secrétariat du programme ENFOR
Service canadien des forêts
Ottawa (Ontario)
K1A 1G5

	Table of Contents/Table des matières
<i>viii</i>	Preface/Préface
<i>xi</i>	Glossary/Glossaire
203	Acknowledgments/Remerciements
	 Tables/Tableaux
1	1. Atmospheric inputs/Apports atmosphériques
10	2. Inputs - nitrogen fixation/Apports - fixation d'azote
15	3. Inputs - rock weathering/ Apports - altération des roches
16	4. Standing crop biomass and nutrient content/Biomasse et teneur en éléments nutritifs du matériel sur pied
56	5. Forest floor biomass and nutrient content/ Biomasse et teneur en éléments nutritifs de la couverture morte
74	6. Forest soil nutrient content/Teneur en éléments nutritifs du sol forestier
91	7. Litterfall biomass and nutrients/Biomasse et éléments nutritifs des chutes de litière
116	8. Defoliation/Défoliation
117	9. Throughfall and stemflow/ Précipitation au sol et écoulement sur écorce
127	10. Litter decomposition/Décomposition de la litière
136	11. Annual uptakes/Absorptions d'éléments nutritifs
140	12. Nutrient concentrations - overstorey/Concentrations d'éléments nutritifs - étage dominant
177	13. Nutrient concentrations - understorey/Concentrations d'éléments nutritifs - sous-étage
189	14. Annual outputs/ Pertes d'éléments nutritifs
193	15. Outputs - denitrification/Pertes - dénitrification
195	16. Water chemistry profiles/Profils chimiques de l'eau
201	17. Fire nutrient outputs/Pertes d'éléments nutritifs attribuables aux incendies
203	References/Références

PREFACE

As the continuing expansion of human population exerts growing pressure on the world's forest resources, the intensity with which forests are managed and harvested must increase. Strategies for the establishment and culture of forest crops will increasingly resemble those of agriculture, and forest management will encounter and have to deal with new problems that have long been recognized by farmers.

The most fundamental aspect of the resource in both forestry and agriculture is the soil. Not only is it a relatively non-renewable or very slowly renewed resource; without adequate soil conditions most forest and agricultural crops simply cannot be grown. Climate is certainly very important but, with a number of notable exceptions, regional climate is not thought to be significantly altered by local land management. The genetic make-up of the biota (crop and non-crop), and the species composition and structural organization of the biotic community, are also very important. But such factors can be manipulated to achieve land management objectives only if there is a soil of adequate fertility. Thus, the character of the soil can be considered the "Achilles heel" of the intensively managed forest ecosystem.

Many characteristics of soil are important to crop production. Physical attributes such as moisture status, structure, aeration, and temperature exert a very significant control on crop growth. They are certainly subject to modification by low- and moderate-intensity management (in certain areas such modifications may be of preeminent importance) but, generally, the physical attributes of the soil are mainly determined by regional climates, geology, and landform position. In unmanaged or low intensity-managed forests, the chemical characteristics of soil also reflect regional climate, geology, and landform position, as well as the past history of ecological succession. As the intensity of forest management increases, there is a potential for adverse changes to both physical and chemical aspects of the soil. The physical changes can be serious, long-lasting, and difficult to rectify. However, they have a lower probability of occurrence than changes in soil chemistry. Loss of soil organic matter, changes in

pH, and alterations in site nutrient status are an almost inevitable outcome of the switch from low to high intensity forest management; these changes will often have a negative impact on future crop production unless appropriate soil amelioration activities and/or site nutrient management are undertaken.

Due to the important implications of intensification of forest management on soil fertility, site nutrient management will become an increasingly vital component of forest crop production in the future. In recognition of this, the ENFOR program supported the development of the FORCYTE computer simulation model (Kimmins and Scoullar 1983, 1984). Users of FORCYTE are required to supply a variety of input data. Because, in some cases, it may be difficult to obtain all of the necessary data, at least initially, it was felt desirable to assemble published estimates of a variety of ecosystem attributes from which estimates could be obtained for various input parameters. Such an assemblage of data would facilitate initial use of ORCYTE while additional data collection is undertaken.

The tables in this report summarize some of the available literature on nutrient inputs to ecosystems, the organic matter and nutrient content of forest ecosystems, nutrient dynamics within ecosystems, internal cycling of nutrients within trees, and outputs of nutrients from forest ecosystems. This job of data assembly is far from complete, and apologies are made to authors whose data have either been missed or have not yet been included. It is intended to bring the tables up to date every few years, and the senior author would be most grateful to receive tabular summaries from authors of data that should be included in the next update of the tables. The tables cover mainly temperate and high latitude/altitude forests. A similar compilation will be undertaken for low latitude forests at some time in the future.

Any comments or suggestions concerning the tables would be welcome, as would notification of any errors that are discovered. A number of additional tables are planned for a subsequent edition. These cover published estimates of a number of parameters added to the tables recently.

PRÉFACE

À cause de la pression démographique sans cesse croissante sur les ressources forestières du globe, celles-ci doivent être aménagées et exploitées de façon plus intensive. Les stratégies d'implantation et de culture ressembleront de plus en plus à celles de l'agriculture, et les aménagistes auront à régler de nouveaux problèmes qui sont depuis longtemps le lot des agriculteurs.

Le facteur capital, en foresterie et en agriculture, est le sol. Non seulement s'agit-il d'une ressource qui se renouvelle relativement peu ou très lentement, mais, si ses caractéristiques ne conviennent pas, la plupart des cultures forestières et agricoles végéteront tout simplement. On ne peut nier l'importance du climat, mais, sauf pour un certain nombre d'exceptions notables, on ne pense pas que, à l'échelle régionale, il soit considérablement modifié par l'aménagement local des terres. Le génotype des espèces (cultivées ou non) ainsi que la composition des espèces et la structure de la communauté biotique sont aussi très importants, mais ces facteurs peuvent être manipulés en fonction des objectifs de l'aménagement seulement si le sol est d'une fertilité convenable. Ainsi, on peut considérer le sol comme le talon d'Achille des écosystèmes forestiers aménagés en intensive.

Beaucoup de caractéristiques du sol sont importantes pour la production végétale. Les caractéristiques physiques telles que l'humidité, la structure, l'aération et la température déterminent la croissance. Elles sont certainement modifiables par l'aménagement peu et moyennement intensif (dans certains endroits, ces modifications peuvent être d'une importance prédominante), mais, en général, elles sont surtout gouvernées par le climat, la géologie et la position des formes du terrain à l'échelle régionale. Dans les forêts non aménagées ou aménagées peu intensivement, les propriétés chimiques du sol traduisent aussi l'influence régionale du climat, de la géologie et de la position des formes du terrain de même que les antécédents des successions écologiques. À mesure que l'aménagement forestier s'intensifie, les caractéristiques physico-chimiques des sols peuvent se dégrader. Les modifications physiques peuvent être graves, durables et difficiles à corriger.

Toutefois leur probabilité est moindre que les modifications chimiques. La perte de matière organique du sol, les modifications du pH et le déséquilibre nutritif des stations sont un résultat presque inévitable du passage de l'aménagement peu intensif à l'aménagement très intensif des forêts; ces modifications auront souvent un effet négatif sur les récoltes ultérieures à moins que des mesures appropriées d'amendement ou de maîtrise de l'équilibre nutritif des stations ne soient adoptées.

À cause des conséquences importantes de l'intensification de l'aménagement forestier sur la fertilité, la maîtrise de l'équilibre nutritif des stations deviendra de plus en plus capitale pour la production forestière. C'est à partir de ce constat que, par le programme ENFOR, on a financé la construction du modèle de simulation informatisée FORCYTE (Kimmins et Scoullar, 1983 et 1984). Les utilisateurs de ce modèle doivent fournir une foule de données d'entrée. Comme, parfois, il peut être difficile d'obtenir toutes les données nécessaires, du moins au début, nous avons pensé qu'il était souhaitable de réunir les estimations publiées sur une foule de caractéristiques des écosystèmes, à partir desquelles on pourrait estimer les divers paramètres d'entrée. Un tel ensemble de données faciliterait au départ l'utilisation du modèle, en attendant l'obtention de données supplémentaires.

Les tableaux réunis dans le rapport résument certaines des données publiées sur les apports d'éléments nutritifs dans les écosystèmes, les concentrations de ces éléments et de matière organique dans les écosystèmes forestiers, la dynamique de ces éléments à l'intérieur des écosystèmes, leur cycle interne dans les arbres et leur exportation à partir des écosystèmes. L'ensemble de données est loin d'être complet, et nous demandons aux auteurs dont nous avons omis ou non encore inclus les données de nous excuser. Nous avons l'intention de mettre à jour les tableaux à des intervalles de quelques années, et l'auteur principal saurait énormément gré à ceux qui lui transmettront des tableaux sommaires de données pour les faire insérer dans les prochaines mises à jour. Les tableaux portent surtout sur les forêts tempérées et les forêts des hautes latitudes et altitudes. Une compilation semblable sera

entreprise pour les forêts des latitudes inférieures, ultérieurement.

Nous serons attentifs à toute observation ou proposition concernant les tableaux ainsi qu'à tout signalement des erreurs qui

pourraient s'y trouver. Nous prévoyons pour une édition ultérieure l'ajout d'un certain nombre de tableaux. Ils porteront sur les estimations publiées d'un certain nombre de paramètres qui viennent d'être ajoutés aux tableaux.

GLOSSARY/GLOSSAIRE

A

aboveground
aboveground parts
acid
acorns
additional input due to impaction

adv. decay
aerial
aerial parts
aerobic scenario
after --
after burn
age
alder
all potentials
anaerobic scenario
andesite parent material
andesitic tuffs
annual outputs
annual shoots
annual uptakes
arboreal lichens
ash
atmosphere particulates
atmospheric inputs
Aug.
avail.
average
av. -- plots

épigée
parties épigées
acide
glands
apports additionnels attribuables à
l'impact
carie avancée
aérienne
parties aériennes
aérobiose
d'après --
après brûlage
âge
aulne
tous les potentiels
anaérobiose
roche-mère andésitique
tufs andésitiques
pertes d'éléments nutritifs
pousses annuelles
absorptions d'éléments nutritifs
lichens corticoles
cendres
particules de l'atmosphère
apports atmosphériques
août
assim.
moyenne
moyenne de -- parcelles

B

bark
basalt parent material
based on accretion studies

based on acetylene reduction assays

based on greenhouse accretion per gram
nodule times nodule biomass in field

based on 9 months data
basic
before burn
below-ground roots
biomass & soil
birch
bird droppings
Black cottonwood

écorce
roche-mère basaltique
d'après des études d'accélération de
croissance
d'après des mesures de la réduction de
l'acétylène
d'après l'accélération de croissance
divisée par le poids (grammes) des nodules
en serre multipliée par la biomasse des
nodules sur le terrain
d'après des données pour 9 mois
basique
avant brûlage
racines sousterraines
biomasse & sol
bouleau
excréments d'oiseaux
peuplier occidental

bogwhortleberry forest
 bole
 bole harvest
 bolewood
 boreal
 branchfall
 broad-leaved
 broadleaves
 brown
 bud scales
 buds
 bulk precipitation (rain & dry fallout)

 buried wood
 burn

C

calculated from
 calculated from per cent weight loss

caralloid roots
 carbohy. fert.
 catkins
 central Europe
 central Sweden
 cited in
 clear-cut
 clear-cut plot
 coarse roots
 coastal
 collector no.
 component
 cones
 conifers
 content
 control
 coralloid roots
 cornus fol.
 crown
 current needles
 current twigs + leaves
 cut

D

dark wood
 dead branches
 dead roots
 dead standing wood plus bark
 decaying logs
 decid. fol.
 deep
 defoliation

forêt à airelle des marécages
 fût
 fûts récoltés
 bois des fûts
 région boréale
 chutes de branches
 à larges feuilles
 larges feuilles
 brune
 écailles de bourgeons
 bourgeons
 précipitations globales (pluies & retombées sèches)
 bois enfoui
 brûlage

teneurs calculées d'après les données de
 calculé d'après le pourcentage de
 diminution du poids
 racines coralliformes
 engrais glucidique
 chatons
 Europe centrale
 centre de la Suède
 in
 coupe rase
 parcelle coupée à blanc
 racines épaisses
 région côtière
 N^o de collecteurs
 composante
 cônes
 conifères
 teneur
 témoin
 racines coralliformes
 feuill. de cornus
 cime
 aiguilles de l'année
 rameaux de l'année + feuilles
 coupe

bois foncé
 branches mortes
 racines mortes
 bois mort sur pied + écorce
 grumes en putréfaction
 feuill. caduc
 profondément
 défoliation

denitrification
depth
detritus
dom. veg.
downslope from cornfields
downslope from hogpens
dry
dry fallout only
dry soil
duff
duration
dust
dwarf shrubs

dénitrification
profondeur
détritus
vég. dom.
en aval de champs de maïs
en aval de porcheries
sec
retombées sèches seulement
sol sec
litière feuillue
durée
poussières
arbrisseaux nains

E

early success
ecosystem
ecosystem with Douglas-fir
entire
epilobium against stems
epiphytes
estimated from graphs
estimated from graphs which are adjusted
to normal stocking
everg. fol.
evergreen
exch.
extract
extr. cations

phase initiale
écosystème
écosystème à douglas taxifolié
total
epilobium sur tiges
épiphytes
estimations à partir de graphiques
estimations à partir de graphiques,
ajustées en fonction d'une densité normale
feuill. semperv.
sempervirante
échang.
extrait
cations extr.

F

fallen logs
feldspar
fert.
field layer
figures may not be additive due to
rounding errors

fine litter
fine material
fine roots
fire nutrient outputs

fire type
floodplain forest stand
flowers
foliage
foliage & twigs
foliage - mid crown
forest
forest floor

grumes tombées
feldspath
engrais
couverture vivante au-dessus du sol
les sommes des chiffres peuvent ne pas
correspondre aux totaux à cause des
erreurs d'arrondissement
litière fine
matières fines
racines fines
pertes d'éléments nutritifs attribuables
aux incendies
type d'incendie
peuplement forestier de zone inondable
fleurs
feuillage
feuillage & rameaux
feuillage - milieu de la cime
forêt
couverture morte

forest floor biomass and nutrient content

forest floor burning

forest soil nutrient content

frass

free-living aerobic

free-living anaerobic

fresh

fruit

fruiting bodies

fruit-stalks

G

good

granitic

grasses

green

greenhouse study

ground layer

ground veg.

H

hardwood

heavy poll.

heavy thinned

hemicell

herbaceous

herbs

high elev. site

high fert.

high productivity

high site

I

in prep.

in review

in root zone

in top -- cm

inputs - nitrogen fixation

inputs - rock weathering

insect bodies

insects

in/mass

irrigated waste water

J

July

June

biomasse et teneur en éléments nutritifs
de la couverture morte

brûlage de la couverture morte
teneur en éléments nutritifs du sol
forestier

excréments d'insectes

aérobies libres

anaérobies libres

frais

fruits

fructifications

pédoncules des fruits

bon site

granitique

graminées

verte

étude en serre

couverture vivante au niveau du sol

couverture vivante

feuillu

poll. élevée

forte éclaircie

hémicellulose

pl. herbacées

herbes

stat. de haute alt.

fert. élevée

productivité élevée

station élevée

en prép.

en révision

dans la zone des racines

dans les premiers -- cm

apports - fixation d'azote

apports - altération des roches

corps d'insectes

insectes

apports/masse

eaux usées d'irrigation

juillet

juin

K

kg/ha/yr
known age

kg.ha⁻¹.an⁻¹
âge connu

L

late success
late summer
lateral root bark
lateral root wood
lateral roots
layer
leachate
leaching
leaf fall
leaf litter
leaves
lge. branches
light wood
lignin
lignin regress
limbs
lime
limestone parent material
litter bag
litter decomposition
litterfall
litterfall biomass & nutrients

live branches
live crown
living biomass
location
logs
low elev. site
low. crown
low fert.
low poll.
low productivity
low site
lowerslope
lysimetry

phase avancée
fin de l'été
écorce des racines latérales
bois des racines latérales
racines latérales
couche
percolat
lessivage
chute des feuilles
litière feuillue
feuilles
grosses branches
bois clair
lignine
régression d'après la lignine
grosses branches
tilleul d'Amérique
roche-mère calcaire
sac à litière
décomposition de la litière
chutes de litière
biomass & éléments nutritifs des chutes
de litière
branches vivantes
cime vivante
biomasse vivante
endroit
grumes
stat. de basse alt.
bas de la cime
fert. faible
poll. faible
faible productivité
station basse
pente inférieure
lysimétrie

M

May
male fl.
mats-bark
mats-wood
maximum values
may be revised before publication
mean as in ¹ & includes large woody
components, eg, down tree & branches
as well as other 01 and 02 components

mai
fl. mâles
grosses racines - écorce
grosses racines - bois
valeurs maximales
pourraient être révisées avant publication
moyenne (comme en ¹) comprenant les
composantes ligneuses importantes, p. ex.
les arbres et les branches tombés, ainsi
que d'autres composantes (01 et 02)

mean values from two watersheds, based
on 0.04 ha plots per watershed

medium roots
med. site
med. thinned
mesic
metashale
method
mid elev. site
mid-slope
middle success
mid. crown
min. horizons
min. soil
misc.
mix
mixed
mixed broad.
mixed decid.
mixed hardwoods
mod. decay
mod. poll.
moist
moist soil
monthly mean
months
mortality
moss & lichens
muck

N

needles
new fol.
no date
no poll.
no thinning
no value
none detected
non-woody
not given
note: some totals do not add up
precisely due to conversion of pound/acre
to kg/ha

nutrient concentrations - overstorey
(% of dry weight)
nutrient concentrations - understorey

valeurs moyennes pour deux bassins
versants pour des parcelles de 0,04 ha
dans chaque bassin

racines moyennes
station moyenne
éclaircie moyenne
mésotique
métashale
méthode
stat. de moy. alt.
milieu de pente
phase intermédiaire
milieu de la cime
horizons minéraux
sol minéral
divers
mélangée
mélangée
mélangée, feuillue
mélangée à feuillage caduc
mélangée de feuillus
carie modérée
poll. mod.
humide
sol humide
moyenne mensuelle
mois
mortalité
mousses & lichens
tourbe évoluée

aiguilles
nouv. feuill.
sans date
sans poll.
sans éclaircie
aucun chiffre
aucune décelée
non ligneuse
non donné
remarque: une conversion des lb/acre aux
kg/ha ayant été effectuée, il se peut que
certains totaux ne correspondent pas aux
chiffres indiqués
concentrations d'éléments nutritifs - étage
dominant (% poids humide)
concentrations d'éléments nutritifs - sous-
étage

O

oak	chêne
oakwood	chênaie
old fol.	vieux feuill.
old growth	vieux peuplement
older	d'années antérieures
older leaves	feuilles plus vieilles
open	terrain dégagé
openland ppt.	précipitations sur terrain dégagé
organic layers	couches organiques
org. horizons	horizons org.
org. layer	couche organique
org. mat.	mat. org.
other	autres
other OM	autres mat. org.
output type	types de pertes
outputs-denitrification	pertes-dénitrification
overstorey	étage dominant

P

parts per million	parties par million
peat	tourbe
periodic ground fires	feux de profondeur périodiques
phyllosphere	phyllosphère
pine needles	aiguilles de pin
<u>Pinus sylvestris</u> on sphagnum	<u>Pinus sylvestris</u> sur sphaigne
poor	médiocre
poor site	station médiocre
precip.	précip.
prelim. data	données prélim.
prescribed broadcast fire	brûlage extensif dirigé
primary branch bark	écorce des branches principales
primary branch wood	bois des branches principales
pumice soil	sol ponceux

R

red alder	aulne rouge
reference	référence
regress C/N	régression sur C/N
reproductive	org. reprod.
reprod.	org. reprod.
resin	résine
rhizomorphs	rhizomorphes
rhyolite parent material	roche-mère rhyolitique
ridgetop	faîte
rock type	type de roches
root crown	collets des rac.
root crown bark	écorce du collet des racines
root crown wood	bois du collet des racines
root depth	profondeur des racines
roots	racines
roots overstorey + understorey	racines - ét. dom. + sous-ét.
root-zone	zone des racines

S

schist
sandstone
sasa litter
saturated zone
secondary
secondary branch bark
secondary branch wood
sedimentary
seedling
seeds
seeps
senescent leaves
Sept.
sev. poll.
shallow
shrub leaves
shrub stems
shrub twig
shrublayer
shrubs
sites
sitka alder
slash
slash fire
slash fire-hot
slash fire-medium
slight-mod. decay
sm. branches
sm. trees
soil
soil leachate
soil org. matter
soil to -- cm
species
spr. needles
springs
sprouts
stand
stand age
standing crop biomass & nutrient content

States' avg.
stem divided into 10 equal sections
stem heart
stem sap
stembark
stemflow
stems
stemwood
SW Western Australia
streamflow
stream-water
strobili

schiste
grès
litière à sasa
zones saturées
secondaire
écorce des branches secondaires
bois des branches secondaires
sédimentaire
semis
graines
infiltrations
feuilles sénescences
septembre
poll. sévère
peu profondément
feuilles des arbrisseaux
tiges des arbrisseaux
rameaux des arbrisseaux
arbrisseaux
arbrisseaux
stations
aulne de sitka
rémanents
feu de rémanents
feu de rémanents - chaud
feu de rémanents - moyen
carie légère à modérée
petites branches
petits arbres
sol
percolat du sol
mat. org. du sol
sol jusqu'à -- cm
espèce
aiguilles d'épinette
sources
rejets
peuplement
âge du peuplement
biomasse & teneur en éléments nutritifs
du matériel sur pied
moy. de -- États
tige divisée en 10 sections égales
cœur de la tige
sève de la tige
écorce des tiges
écoulement sur écorce
tiges
bois des tiges
Australie occidentale (S.-O.)
cours d'eau
cours d'eau
strobiles

stumps
successional sere
sugars
summary
surface runoff

souches
série
sucres
résumé
ruissellement

T

tap root bark
tap root wood
terminal shoots
tertiary (termi.) branch bark
tertiary (termi.) branch wood
tether
thinning
thinning residue piled and burned
to sampled depth
top root
total annual prec.
total in zone of max. rooting
total litter
total non-symb.
total rooting zone
total to -- m
trees
tree mortality
trees-shrubs
trees - deep
trees - shallow
trenched plots
tropical forest
trunks
tuffs/breccias
twigs
twigs & foliage
throughfall

écorce des racines principales
bois des racines principales
pousses terminales
écorce des branches tertiaires (term.)
bois des branches tertiaires (term.)
attache ("tether")
éclaircie
brûlage de résidus d'éclaircie en tas
jusqu'à la profondeur d'échantillonnage
rac. princ.
prec. ann. tot.
total dans la zone d'enracinement maximal
litière totale
total - non-symb.
total - horizon racinaire
total jusqu'à -- m
arbres
arbre mortalité
arbres-arbrisseaux
arbres - profondément
arbres - peu profondément
parcelles creusées de sillons
forêt tropicale
troncs
tufs/brèches
rameaux
rameaux & feuillage
précipitation au sol

U

ultrabasic
underground parts
understorey
uneven
unfert.
unid'd
unplanted
unpubl. data
upper slope
upp. crown
urban

ultrabasique
parties souterraines
sous-étage
divers
sans fert.
non id.
terrain non planté
données inédites
pente supérieure
haut de la cime
milieu urbain

V

vacc. myrt.
vacc. vitis
varied
various
vines
volcanic
volume loss

vacc. myrt.
vacc. vitis
variée
varié
lianes
volcanique
perte en volume

W

water chemistry profiles
waxes
weight
wet
whole tree crop
-- whorl from top
wildfire
wire screen
wood
woodpecker
woody
woody litter

profils chimiques de l'eau
cires
poids
mouillé
arbres entiers
-- verticille du haut
incendie involontaire
tamis métallique
bois
pic-bois
ligneuse
litière ligneuse

X

xeric

xérique

Y

yellow

jaune

1 yr. needles

aiguilles de l'année

Table 1 Atmospheric Inputs (Kg/ha/yr.)¹

Location	Dom. Veg.	Total Annual Prec. (cm.)	N	P	K	Ca	Mg	Na	Other	Reference
Ontario, Canada			4.95	.09	8.09	11.18	.84			Foster 1974 ^a
Ontario, Canada			6.53	.20	2.11	9.5	8.76	10.48	Fe 1.38 SO ₄ 26 Cl 2.69	Kramer 1976 ^a
Ontario, Canada			6.8	.06	1.56	4.01	.68	1.82	Fe 1.18 SO ₄ 26.70 Cl 6.66	Swanson 1976 ^a
N. Carolina, USA			8.8		.11	2.1	4.8			Swank 1979
Denmark		60	6.9		3.1	6.5	3.0			Jensen 1962
Washington, USA		75	1.2	-	0.27	2.63	0.17	0.49		Tiedeman et al. 1978
Santa Ynez Mt., California, USA		77	NH ₄ 0.1 NO ₃ 1.1	-	0.5	1.9	1.0	6.1		Schlesinger & Hasey, 1980
Ontario, Canada		99.3	10.1 10.8	.41 .28	1.59 1.14	6.76 5.78	1.02 .81	4.02 3.93	Fe 1.47 Fe .85 SO ₄ 29.60 SO ₄ 30.80 Cl 3.14 Cl 2.29	Scheider et al. 1979
New York, USA		116			7.3	9.8	19.1	141.5		Art et al., cited in Gray and Schlesinger 1981
Kyoto, Japan		174	6.42	.56	2.8	10.35	2.15			Maruyama et al. 1965
Kiryu, Japan		193 197 181 197	5.39	.62 .57 .9	2.59 7.34 5.2	10.72 9.8 5.0	2.64 1.91 1.9	5.42 10.82 4.7		Tsutsumi 1978
Jaku, Japan		179	1.72	.52	6.42	9.2	1.77	18.45		
Hier, Japan		260	4.37	1.89	7.8	5.28	2.19	11.8		
Kawigamo, Japan		141	4.77	.28	1.67	8.72				
		169	6.11	.53	3.19	9.93	1.13			
		169	2.99	.24	4.52	10.57	1.11			
Kyoto U., Japan		94	8.06	.85	3.57	11.5	2.03			
Ashtu, Japan		171	9.35	.70	6.98	21.0	9.93			
		140	8.71	.31	3.68	3.93	3.57			

Table 1 Atmospheric Inputs (Kg/ha/yr.)¹

Location	Dom. Veg.	Total Annual Prec. (cm.)	N	P	K	Ca	Mg	Na	Other	Reference
Ontario, Canada		16		.74						Nichols & Cox 1978 ¹
Ontario, Canada				.44					Fe 4.54	Cross 1977 ¹
Michigan, U.S.A.	?	79	NH ₄ -N 3.1 NO ₃ -N 4.9	0.25	2.7	10.5	1.7	3.8	Cl 9.4 SO ₄ 18.2 PH 5.35 Fe 0.4 PH 5.27 SO ₄ 69	Richardson and Merva 1976
?	?	73	NH ₄ -N 2.1 NO ₃ -N 3.2	0.31	3.2	9.5				
Urban		69	NO ₃ -N 4.4	1.21						
Washington, USA	Abies amabilis	273	1.3	.4	.8	.6	.1			Turner & Singer, 1976
B.C., Canada	Abies, Tsuga	315	2.7	.11	2.5	3.7	3.0			Scrivner, 1975 ¹
New Hampshire, USA	Acer, Betula, Fagus		6.5	.04	.9	2.2	.6			Whittaker in Cole Rapp 1980
New Hampshire, USA	Acer, Fagus	130	20.7	.04	.09	2.2	.6	1.6		Likens et al. 1977
New York, USA	Acer, Tilia	96	9.7	.07	.8	14.9	1.4	2.3		Likens, 1972 ¹
Washington, USA	Alnus rubra	137	1.7	.3	2.2	2.2	.5			Turner et al. 1977
Alaska, USA	Betula papyrif.		2.1	.09	.16	.98	.06		Org. Mat. 37.21	Van Cleave in Cole & Rapp 1980
Norway	Betula, Picea Pinus	39	NH ₄ 1.5	tr.	0.5	0.5	0.5	4.3	Cl 6.6	Hornqvist and Joranger 1974 ¹
Minnesota, U.S.A. White	Betula, Pinus	36	2.85	0.31	1.92	6.03	0.82			Comerford and 1977 ¹
Birkenes Watershed, Norway	Betula, Pinus	134	14.5		2.2	2.7	2.3			Gjessing et al. 1976
Japan	Camptothecis Mixed		9.4 3.5	.7 .24	7.0 4.5	19.6 10.6	10.0 1.1			Tsutsumi 1977

Table 1 Atmospheric Inputs (Kg/ha/yr.)¹

Location	Dom. Veg.	Total Annual Prec. (cm.)	N	P	K	Ca	Mg	Na	Other	Reference
Norway	Conifers	77	-	-	8-20	5-17	2	7-22		Haughtbotn 1973 ¹
Mt. Disappointment, Victoria, Australia	Eucalyptus obliqua	98			2.0	2.74	5.4	16.8		Attiwill, 1966.
California, USA	Eucalyptus	57	2.0	0.8	1.7	2.2	0.3	6.6		McColl & Bush, cited in Schlesinger & Gray, 1981
Stradbroke Is., Queensland, Australia	Eucalyptus	165	60	<.2	3.4	3.2	5.9	50		Westman 1978
Maroondah, Victoria Australia	Eucalyptus regnans	151	1.2	.2	3.9	6.6	2.9	14.1		Feller unpubl. data
	Eucalyptus obliqua	102	.7	.2	1.3	4.1	1.8	11.2		
Stewart's Creek, Victoria Australia	Eucalyptus obliqua	130			4.2	1.3	1.4	17.9		Guthrie et al. 1978
A.C.T., Australia	Eucalyptus	150		.33		7.0	2.0	2.5		Hallam, 1976 ¹
Denmark	Fagus	?	-	2.20	15.1	18.0	5.3	18.9		Astrup and Bulow-Olsen 1972 ¹
	Fagus	?	-	2.20	15.1	18.0	5.3	18.9		
France	Fagus	55	NH ₄ 5.1 NO ₃ 4.7	0.3	2.4	9.0	2.9			Lemee 1974 ¹
Central Europe	Fagus	23.7	23.7	.71	3.8	13.9	2.2	8.2		Ulrich 1975
W. Germany	Fagus silvatica	23.9 ¹	23.9 ¹	.48 ¹	2.0 ¹	12.4 ¹	1.79 ¹	7.3 ¹	Al 3.1 ¹ Cl 17.8 ¹ Fe 1.17 ¹ H .83 ¹ Mn .22 ¹ S 24.8 ¹	Ulrich & Mayer 1972
Soiling, W. Germany	Fagus silvatica	93.8	21.9 ^{1,2}	.17 ^{1,2}	12.1 ^{1,2}	21.2 ^{1,2}	3.9 ^{1,2}	12.4	S 48.4 Cl 30.1	Ulrich et al. 1979
	Picea abies	93.8	21.9 ^{1,2}	.17 ^{1,2}	21.5 ^{1,2}	27.3 ^{1,2}	4.8 ^{1,2}	16	S 85.3 Cl 35.9	

Table 1 Atmospheric Inputs (Kg/ha/yr.)¹

Location	Dom. Veg.	Total Annual Prec. (cm.)	N	P	K	Ca	Mg	Na	Other	Reference
S. Sweden	Fagus, Picea	95	8.2	.07	1.9	3.5	.91			Nihlgard 1970
New Zealand	Hardwood	260	2.81	.26	5.72	2.08	3.9	28.9		Neary et al. 1978
Tennessee, U.S.A.	Hardwoods	?							S04 13	Lindberg et al. 1979 ^a
Florida, U.S.A.	Hardwoods	112	-	0.9	8.2	19.3	2.9			Ewel et al. 1975 ^a
N. Carolina, U.S.A.	Hardwoods		3.5	.88	.28	3.4	1.7			Wells et al 1972
New York, USA coastal	Ilex				6.2	8.6	11.5			Art et al. 1974
					6.2 ^a	7.4 ^a	19.8 ^a			
Tennessee, USA	Liriodendron		7.7	.06	.73	6.1				Harris in Cole & Rapp 1980
				.7 ^a	2.56 ^a	6.1 ^a				
Tennessee, USA	Liriodendron, Carya, Quercus		8.7	.06	1.0	9.1	1.0			Harris in Cole & Rapp 1980
				.48 ^a	2.2 ^a	5.3 ^a	1.1 ^a			
Ohio, U.S.A.	Locust, Pinus	89		.18						Taylor et al. 1971 ^a
Kyoto, Japan	Mixed broad Chamaecyparis Camptotheca	146 169 171	5.5 3.5 9.4	.5 .2 .7	2.7 4.5 7.0	8.8 10.6 19.6		1.3 1.1 9.9		Iwatsubo 1976
Great Britain	Mixed decid		5.8	.2	3.3	6.9	5.4			Satchell in Cole & Rapp 1980
Tennessee, USA	Mixed hardwoods	150	6.9	0.6	4.2	4.6				West et al. 1981 (prelim. data)
New Hampshire, USA	Mixed hardwoods		NO3-N 6.0 NH4-N 2.8		2.4	3.1	0.7	1.3	S04-18 S04-S-18	Martin 1979
Silverstream, New Zealand	Nothofagus	135	2.2	.20	5.3	6.0	9.0			Miller 1963
Alberta	Picea	?								S04 0.3-2.4 Baker et al. 1977 ^a

Table 1 Atmospheric Inputs (Kg/ha/yr.)

Location	Dom. Veg.	Total Annual Prec. (cm.)	N	P	K	Ca	Mg	Na	Other	Reference
USSR	Picea abies		1.1		1.0	2.3	.9			Kazimirov & Morozova 1973
Scotland	Picea sitch. Picea sitch. Picea sitch. Picea sitch.	1530 1620 1020 1120				1 4 2 2	10 9 8 10	41 23 21 45		Miller 1979
N. Carolina, USA	Picea, Abies Betula lutea	117			4.1 5.6	6.3 7.8	.9 1.0			Weaver 1972
New Mexico, U.S.A.	Picea, Abies	74			1.4	6.4	.6			Gosz 1977
Norway	Picea, Pinus, Betula	47	NH4 1.4 NO4 1.6	0.02	0.6	0.9	0.7	7.0	Cl 9.9 SO4 4.9	Abrahamson et al. 1976
Sweden	Pinus	?	1.8	-	0.51	0.76	0.14	0.57	Cl 2.59	Bringmark 1980
England	Pinus	12							SO4 5.8	Bache 1977
New Zealand	Pinus	69	-	0.3	4-8	3-4		30		Will 1959
Scotland	Pinus	79	-	-	-	5.6	4.0		SO4 14	Nicholson et al. 1980
Ireland	Pinus	85	-	-	11	11	5.3	118		O'Hare 1967
New Mexico, U.S.A.	Pinus	48			1.6	6.7	.7			Gosz 1977
Ontario, Canada	Pinus banksiana	86	7.9	.1	4.0	5.6	.8			Foster & Morrison 1976
Tennessee, USA	Pinus echinata		8.7	.06	1.0	9.1	1.0			Harris in Cole & Rapp 1980
Scotland	Pinus nigra Pinus nigra	630	4.8 tr	.04 tr	2.8 6.9	2.9 3.5	2.6 2.1	25.2 15.2		Miller, Cooper & Miller 1976
New Zealand	Pinus radiata	141			7.6	1.6	1.4	9.6		Knight & Will 1977

Table 1 Atmospheric Inputs (Kg/ha/yr.)¹

Location	Dom. Veg.	Total Annual Prec. (cm.)	N	P	K	Ca	Mg	Na	Other	Reference
N. Carolina, USA	Pinus strobus	5.5 3.3*	5.4	.21	1.6	2.8				Swank in Cole & Rapp 1980
Washington, U.S.A.	Pinus taeda									Wells & Jorgensen 1975
Georgia, U.S.A.	Pinus, hardwoods	?								Torrenewva 1975*
Finland	Pinus, Picea	57	6.0	.1	2.4	2.0	1.0	3.2		Viro 1953*
	Pinus	28	6.6	.14	3.9	4.9				Malonen 1974
Minn. USA	Pinus, Picea	70		.14						Wright 1974*
Storefjon, Sweden	Pinus, Picea	87		.14	1.7	3.6	1.9			Dickson 1976*
Valen, Sweden	Pinus, Picea	72			1.6	5.9	1.2			Eriksson 1974*
Ontario, Canada	Pinus, Picea	83	6.4	.32	1.1	3.8	.9			Schindler et al. 1976
Michigan, USA	Populus tremuloides	80	NH ₄ -N 4.1 NO ₃ -N 2.1	0.2	2.5	8.3	1.7	3.3		Richardson & Lund 1976
New Mexico, USA	Populus	72			1.3	6.8	.7			Gosz 1977*
Minn. USA	Populus, Picea	76	7.3	.5	1.0	3.5	.7	1.1		Verry & Timmons 1977
Washington, U.S.A.	Pseudotsuga	140							SO ₄ 12.5	Cole and Johnson 1977*
Washington, USA	Pseudotsuga menziesii		1.7	2.3	2.5	0.3	.5			Turner, Cole in Cole & Rapp 1980
Washington, USA	Pseudotsuga menziesii		2.0	0.3	1.2	3.1	1.2			Grier in Cole & Rapp 1980
New Zealand	Pseudotsuga			.6	10	4.		40		Will 1959
Oregon, USA	Pseudotsuga	251 215	1.1 .9	.27	.3 .1	7.6 2.3	.7 .1	1.2 2.3		Fredriksen 1972

Table 1 Atmospheric Inputs (Kg/ha/yr.)¹

Location	Dom. Veg.	Total Annual Prec. (cm.)	N	P	K	Ca	Mg	Na	Other	Reference
Washington, USA	Pseudotsuga	136	1.1	Tr.	.8	2.8	.7			Cole et al. 1967
Oregon, USA	Pseudotsuga	230		.23	.1	2.1	2.1			Abee & Lavender 1972
France	Quercus	?	25	0.04	7.5	2.5	-	-		Aussenae et al. 1972 ^a
Hungary	Quercus	60	20	1.3	7.4	17	2.3	1.5	Cl 13 SO ₄ 18	Szabo and Csontos 1975 ^a
Oklahoma, U.S.A.	Quercus	86	3.9	1.07	4.0	3.9	0.86			Johnson and Risser 1974 ^a
England	Quercus	110	5.8	0.5	3.0	4.8	1.4		504 5.6	Brown 1974 ^a
Belgium	Quercus		8.7		4.0	15.0				Duvigneaud, Denaeayer in Cole & Rapp 1980
Meathop Wood UK - coastal	Quercus			.34 .12 ^a	4.0 6.3 ^a	8.8 4.2 ^a	6.8 16.2			White and Turner 1970
Belgium	Quercus	85	6.0		2.9	9.1	2.3			Duvigneaud & Denaeayer-de Smet 1967
Lancashire, UK	Quercus	162	9.5	.43	3.0	7.3	4.6	35.3		Carlisle et al. 1967
France	Quercus Quercus Quercus Pinus	477 601 662 709		.70 .80 1.00 1.10	3.1 3.8 2.0 3.8	14.7 10.2 10.5 11.7	2.1 1.7 1.5 1.0			Rapp 1969
Tennessee, USA	Quercus alba		8.7	.06 .48 ^a	1.0 2.2 ^a	9.1 5.3 ^a	1.0 1.1 ^a			Harris in Cole & Rapp 1980
France	Quercus ilex		15.6	1.0	2.4	11.7	2.1			Loissant, Rapp in Cole & Rapp 1980

Table 1 Atmospheric Inputs (Kg/ha/yr.)¹

Location	Dom. Veg.	Total Annual Prec. (cm.)	N	P	K	Ca	Mg	Na	Other	Reference
Belgium	Quercus mixed	13.0	5.8	5.0	19.0				Org. Mat. 1	Duvigneud, Deneyer in Cole & Rapp 1980
Tennessee, USA	Quercus prinus	8.7	.06	1.0	9.1	1.0				Harris in Cole & Rapp 1980
Illinois, USA	Quercus, Carya	17.7	1.3	12.1	11.1	1.7				Rolfe, Akhtar & Arnold 1978
N. Carolina	Quercus, Carya	170	-	4.8	4.4	0.8	6.8			Best and Monk 1975 ^a
N. Carolina, USA	Quercus, Carya	4.9	2.1	4.8						Swank in Cole & Rapp 1980
N. Carolina, USA	Quercus, Carya	185	3.2	6.2	1.3					Nat'l Academy of Sciences 1974 ^a
Illinois, USA	Quercus, Carya Liriodendron	98	1.8	1.0	.5	6.7	.02			Brown 1980
Tennessee, USA	Quercus, Carya	155	.54	3.1	14.3	2.1				Henderson 1976 ^a
N. Carolina, USA	Quercus, Carya	170-250	3.02	.17	1.11	5.84				Swank & Henderson 1976
Tennessee, USA	Quercus, Mix	153	7.8	.06	1.09	5.82	1.0			Swank & Henderson 1976, Henderson 1977
Spain	Quercus, Pinus	63	8.1	-	3.8	7.2	1.3	25.6	Cl 9.1	Calvo de Anta et al. 1979 ^a
New York, USA	Quercus, Pinus	124			2.4	3.3	2.0			Woodwell & Whittaker 1967
SE. USA	Quercus, Pinus	127			1.0	6.0	2.0			Gambell & Fisher 1966 ^a

Table 1 Atmospheric Inputs (Kg/ha/yr.)¹

Location	Dom. Veg.	Total Annual Prec. (cm.)	N	P	K	Ca	Mg	Na	Other	Reference
U.S.A.	Taxodium	110.5	5.8	0.49	3.0	4.8	1.43		5 0.49	Brinson et al. 1980
B.C., Canada	Tsuga, Thuja	225-255	3.5-3.9	.0	.8-.9	3.4-3.9	.8-.9	4.1-4.6		Feller & Kimmins 1979
Sweden	Varied	42-65			.6-3.7	2.6-13.9	.6-2.6			Tamm 1958
SE. England	Varied	83			2.8	10.7	<4	19.3		Madgewick & Ovington 1959

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- ¹ Bulk precipitation (rain & dry fallout)
² Additional input due to impaction
³ In Likens et al, 1977
⁴ Dry fallout only
⁵ In Scheider 1979
⁶ Atmosphere particulates
⁷ Openland ppt.
⁸ Cited by Parker 1983.

Table 2 Inputs - Nitrogen Fixation

Location	Dominant Veg.	Age	Source	Amt (kg/ha/yr)	Reference
Quebec, Canada			Free living aerobic		Knowles 1965
			St. Bernard	34.6	
			muck	7.0	
			muck	9.3	
			mull A1	5.0	
			Free living anaerobic		
			St. Bernard	31.7	
			St. Bernard	73.0	
			Muck	19.8	
			Muck	39.0	
			Mull L+F	.1	
			Mull A1	44.0	
			Mull A1	55.2	
			Mor L	.8	
			Mor F+H	.9	
Alaska, USA	Alnus cri.	5		362	van Cleve et al, 1971
Alaska, USA	Alnus cri.	10-60	Nodules	40	Crocker & Dickson, 1957
Alaska, USA	Alnus cri.	0-40		62	Crocker & Major, 1955
Quebec, Canada	Alnus glutinosa	2	Ecosystem	53	Cote and Camire, 1984
	Alnus glutinosa & Populus	2	Ecosystem	16-34	
England, UK	Alnus glutinosa	5-20	Ecosystem	58	Akkermans and van Dijk, 1976
England, UK	Alnus glutinosa	7	Greenhouse study	30	Virtanen 1957 (cited in Tarrant and Trappe, 1971)
England, UK	Alnus glutinosa	11	Soil to 5cm	12	Holmsgaard 1960 (cited in Tarrant and Trappe, 1971)
Norway	Alnus incana	30	Ecosystem	43	Johnsrud, 1979
Norway	Alnus incana	30	Ecosystem	43	Johnsrud, 1978
Washington, USA	Alnus rubra	23	Ecosystem	42	Binkley, 1983
Washington, USA	Alnus rubra	10-30	Soil to 120 cm	60	Heilman, 1983

Table 2 Inputs - Nitrogen Fixation

Location	Dominant Veg.	Age	Source	Amt (kg/ha/yr)	Reference
Washington, USA	Alnus rubra	2-5	Ecosystem ¹	150	Heilman and Ekuan, 1983
Oregon, USA	Alnus rubra	0-40	Soil to 90 cm ¹	140	Franklin et al., 1968
Washington, USA	Alnus rubra	0-14 14-24 24-65	Ecosystem ¹ Ecosystem ¹ Ecosystem ¹	160 75 30	Luken and Fonda, 1983
Washington, USA	Alnus rubra	5	Ecosystem ¹	70	Bormann, 1981
Washington, USA	Alnus rubra	38	Ecosystem ¹	85	Cole et al., 1978
B.C., Canada	Alnus rubra	23	Ecosystem with Douglas-fir	130 ¹ 65 ¹	Binkley, 1981/1983
Oregon, USA	Alnus rubra	4	Soil to 15cm ¹ with black cottonwood	32	DeBell and Radwan, 1979
Oregon, USA	Alnus rubra	0-30	Soil to 90 cm ¹	40	Tarrant & Miller, 1963
Oregon, USA	Alnus rubra	0-17	Soil to 15cm ¹ with Douglas-fir	13	Berg and Doerksen, 1975
Oregon, USA	Alnus rubra	0-17	Soil to 15 cm ¹ with Douglas-fir	51	
Oregon, USA	Alnus rubra Alnus rubra Alnus rubra	0-1 7 30	Ecosystem ¹ Ecosystem ¹ Ecosystem ¹	100 140 209	Zavitkovski and Newton, 1968
Washington, USA	Alnus rubra	2-3	Ecosystem ¹	62	Tripp et al., 1979
Washington, USA	Alnus rubra	0-40	Ecosystem Forest floor ² Soil to 20 cm ¹	100+	Bormann and DeBell, 1981
Oregon, USA	Alnus rubra	0-40	Soil to 90cm ¹ with Douglas-fir	25	Franklin et al., 1968
Washington, USA	Alnus rubra	0-4	Soil to 15 cm ¹	80	DeBell and Radwan, 1979
Oregon, USA	Alnus rubra		Symb.	320	Newton et al. 1968

Table 2 Inputs - Nitrogen Fixation

Location	Dominant Veg.	Age	Source	Amt (kg/ha/yr)	Reference
Alaska, USA	<i>Alnus rugosa</i>	0-16	Ecosystem ¹	85	Voight and Steucek, 1969
Quebec, Canada	<i>Alnus rugosa</i>	18		170	Daly, 1966
Alaska, USA	<i>Alnus rugosa</i>	0-30	Soil to 20 cm ¹	56	von Oberforter et al., 1925 (cited in Tarrant & Trappe)
Alaska, USA	<i>Alnus rugosa</i>	0-22	Soil to 70 cm ¹	56	Ovington, 1956b
Washington, USA	<i>Alnus sinuata</i> <i>A. sinuata</i> & <i>Pseudotsuga</i>	2-5 2-5	Ecosystem ² Ecosystem ³	150 17-63	Heilman and Ekuan, 1983
B.C., Canada	<i>Alnus sinuata</i>	5	Ecosystem ¹	35	Binkley, 1982
B.C., Canada	<i>Alnus sinuata</i>	21	Ecosystem with Douglas-fir	20 ¹ 35 ¹	Binkley, 1981/1984
Alaska, USA	<i>Alnus sinuata</i>		Forest floor + A horizon	24	Ugolini 1968
Australia	<i>Casuarina</i>	0-13	Biomass & soil ¹	58	Dommergues, 1963
Oregon, USA	<i>Ceanothus velutinus</i>	0-12	Soil ¹ to 30 cm Ecosystem ¹	41-48 94-100	Binkley et al., 1982
Oregon, USA	<i>Ceanothus velutinus</i>	0-10 10-15	Ecosystem ¹ Ecosystem ¹	110 40	Youngberg & Wollum, 1976 Youngberg et al., 1979
B.C., Canada	<i>Ceanothus sanguineus</i>	0-14	Soil ¹ to 15 cm Ecosystem ¹	40-60 60-90	Binkley and Husted, 1983
Oregon, USA	<i>Ceanothus velutinus</i>	0-17 17-32	Ecosystem ¹ Soil ¹ to 15 cm	0-20 0-17	Zavitkovski and Newton, 1968b Binkley, unpublished
Oregon, USA	<i>Ceanothus velutinus</i>	11	Ecosystem ¹	32	McNabb et al., 1979
Montana, USA	Conifer		Logs	.75	Larsen et al., 1978
Norway	Conifers		Total non-symb.	1.2	Hovland, 1978

Table 2 Inputs - Nitrogen Fixation

Location	Dominant Veg.	Age	Source	Amt (kg/ha/yr)	Reference
Oregon, USA	Conifers	450	Arboreal lichens	3-4	Denison, 1979
New Zealand	Coriaria	14-25	Biomass & soil	130-190	Silvester, 1969
Australia	Eucalyptus & Daviesia	?	Ecosystem	5-7	McColl and Edmonds, 1983
Georgia, USA	Hardwood		Logs	.89	Cornaby and Waide, 1973
Europe	Hippophae	3-16	Ecosystem	4-180	Stewart and Pearson, 1967
Europe	Hippophae	2-15	Ecosystem	2-15	Akkermans, 1971
Western Australia	Macrozamia riedlei		Coralloid roots	18.7	Holliday and Pate, 1976
Tennessee, USA	Mix dec.		Twigs Branches	.27 .08	Todd et al., 1975
			Logs	.09 .30 .92	
			L horizon	.03	
			H horizon	.63	
			Soil 0-10 cm	4.04	
			10-20 cm	1.77	
			20-40 cm	2.72	
			Total	10.85	
Massachusetts, USA	Myrica gale	?	Ecosystem	37	Schwintzer, 1983
Scotland	Myrica gale		Symb.	30	Sprent & Scott, 1979
Oregon, USA	Pseudotsuga	450	Decaying logs	1.4	Silvester et al., 1982
New Zealand	Pinus		Symb. (Coriaria)	90	Harris & Morrison, 1958
New Zealand	Pinus radiata	4 0-4	Lupinus Lupinus	90 160	Gadgil, 1976
England, UK	Pinus sylvestris		Total system	48.2	Ovington, 1951 (from Moore, 1966)
Clemson, S.C., USA	Pinus taeda	40 clearcut	Forest floor Soil Forest floor Soil	0.15 1.60 0.11-0.31 1.73-1.79	West et al., 1981

Table 2 Inputs - Nitrogen Fixation

Location	Dominant Veg.	Age	Source	Amt (kg/ha/yr)	Reference
S. Carolina, USA	Pinus taeda		Soil	1.0	Jorgensen & Wells, 1971
Sweden	Pinus, Picea	15-16	Phyllosphere Forest floor Soil	0-0.15 0-7.5 0-0.5	Granhall and Lindberg, 1980
England, UK	Pseudotsuga		Phyllosphere	5-12	Jones, 1970
Oregon, USA	Purshia trid.		Symb.	.06	Dalton & Zobel, 1979
N. Carolina, USA	Quercus, Carya		Phyllosphere Bole Woody litter Leaf litter Soil	.22 1.00 1.66 .63 8.55	Swank, 1979
N. Carolina, USA	Robinia Pseudoacacia	4-38	Ecosystem ¹	30-75	Boring and Swank a&b
England, UK	Varied		Non-symbiotic	55.7	Ovington, 1956 (from Moore, 1966)

¹Based on accretion studies^aBased on greenhouse accretion per gram nodule times nodule biomass in field.^bBased on acetylene reduction assays.

Table 3 Inputs - Rock Weathering (kg/ha/yr)

Location	Dom. Veg.	Rock type	P	K	Ca	Mg	Na	Other	Reference
Idaho, USA	Conifers	Plagioclase, K-Feldspar	23	26	10	52	Fe 11		Clayton, 1979
Maroondah, Victoria, Australia	Eucalyptus	Dacite	2.7	20.8	18.6	8.4	16.9		Feller 1981
New Hamp. USA	Mixed	Quartz Plagioclase Biotite	7.1	21.1	3.5	5.8	Al 1.9 Si 18.1		Likens et al., 1977
Maryland, USA	Mixed	Schist	2.3	1.3	1.7	2.6	Si 119		Cleaves et al., 1970
Maryland, USA	Mixed	Serpentinite	tr	tr	34.1	tr	Si 55.8		Cleaves et al., 1974
California, USA	Pinus arist.	Dolomite Adamellite	4 8	86 17	52 2	2 1	Si 32 21		Marchand, 1971
Washington, USA	Pseudotsuga		15.2	17.4					Cole et al., 1967
Oregon, USA	Pseudotsuga manziessii	Andesitic tuffs	0.2	4.7	120	7.2	47		Sollins et al., 1980
Oregon, USA	Pseudotsuga	Tuffs/ breccias	1.6	47	11.6	28	Si 213		Fredriksen, 1972
Luxembourg	Quercus, Fagus	Metashale	.2	8.7	15.7	9			Verstraten, 1977
New York, USA	Quercus, Pinus		11.0	24.3	8.3	6.8			Woodwell & Whittaker, 1967

Table 4 Standing Crop Biomass & Nutrient Content

Location	Dom. Veg.	Age	Component	Biomass	kg/ha			P	K	Ca	Mg	Other	Reference
					N								
Japan	Abies (forest)		Aboveground	129000	527	63	278	515	415				Tsutsumi 1971
Oregon, USA	Abies amab.	175	Aboveground	469000	372	67	980	1046	160				Turner & Singer, 1976
Minnesota, USA	Abies balsamea	60	Understory	942	10.1	1.7	13.1	7.6	1.3				Outcalt & White 1981
		cut	Understory	4181	50.3	7.9	64.3	42.8	7.7				
		cut+ burn	Understory	2604	36.4	5.8	55.4	21.7	5.2				
Oregon, USA	Abies concolor	23	Foliage		89.0	11.0	61.0	57.0	12.0				Grier unpublished
			Branches		52.0	4.0	54.0	28.0	7.0				in Cole et al., no date
			Stems		29.0	11.0	37.0	37.8	10.0				
			Understory		29.0	14.0	35.0	35.0	2.0				
			Roots		23.0	4.0	17.0	26.0	4.0				
Oregon, USA	Abies concolor	180	Foliage		170.0	21.0	117.0	260.0	41.0				Grier unpublished
	Tsuga heterophylla		Branches		20.0	9.0	120.0	120.0	40.0				in Cole et al., no date
			Stems		150.0	40.0	650.0	640.0	75.0				
			Understory		12.0	2.0	16.0	15.0	1.0				
			Roots		133.0	25.0	100.0	154.0	25.0				
Japan	Abies firma	97-145	Overstory:										Ando in Cole & Rapp 1980
			Foliage Total	15134	145.7	12.3	157.4	125.6	14.4				
			Branches	57760	173.7	22.5	255.8	315.5	33.8				
			Boles	306668	254.0	46.9	1012.3	961.0	81.7				
			Roots	145647									
			Understory										
			vag.	121957	363.4	40.0	436.9	851.6	52.4				
Colorado, USA	Abies lasiocarpa		Trees >1.4m										Snell et al., 1979
			Needles	22730	223	6	123	201	20				
			Branches	31450	79	13	44	152	13				
			Bole, Bark	172570	384	64	224	481	42				
			Roots	57818	72	12	40	140	12				
			Trees <1.4m	1081	5	1	3	7	2				
			Shrubs	337	4	<1	1	2	1				
			Herbs	39	1	<1	1	1	<1				
Prince George, B.C., Canada	Abies lasiocarpa	110-350	Total		103.9	19.3	63.0	131.1	18.0				Kimmins, 1974
			Wood	2767	14.4	1.2	22.7	21.2	5.1				
			Bark	6459	21.3	3.8	9.4	49.5	3.3				
			Lge. branches	1696	2.9	.4	1.4	8.5	.7				
			Sm. branches	3514	6.3	1.0	3.5	11.0	1.2				
			Twigs&foliage	4454	35.1	5.6	10.4	16.0	3.4				
			Crown	9662	44.3	7.0	15.3	35.5	5.3				
			Bole	34106	35.7	5.0	32.1	70.7	8.4				
			Roots		23.9	7.3	15.6	24.9	4.3				
			Total aboveground		80.0	11.9	46.7	106.2	13.7				

Table 4 Standing Crop Biomass & Nutrient Content

Location	Dom. Veg.	Age	Component	Biomass	kg/ha		P	K	Ca	Mg	Other	Reference
					N							
Japan	Abies mayriana	Not Given	Leaves	28500	324	34.6	144	163	146			Tsutsumi 1971
			Trunks	19400	89	15.5	52.4	109	81.5			and Kawahara
				81500	114	13.0	81.5	243	187			and Tsutsumi 1972
Oregon, USA	Abies nobilis	130	Foliage		149.0	44.0	96.0	144.0	18.0			Grier unpublished
			Branches		75.0	20.0	63.0	170.0	19.0			in Cole et al.
			Stems		390.0	40.0	72.0	510.0	80.0			
			Understory		2.0	t	2.0	15.0	2.0			
U.S.A.	Abies, Tsuga	175	Aboveground	337000	320	50	819	992	130	Mn 258		Turner & Singer 1976
New Hampshire, USA	Acer, Betula	55	Stand	161070	532	87	218	484	49			Whittaker et al. 1974
New Hampshire, USA	Acer, Betula, Fagus	110	Overstory:									Whittaker in Cole & Rapp 1980
			Foliage Total	3180	70.1	5.5	30.0	19.5	4.8			
			Branches	38980	162.5	16.2	52.9	189.3	13.8			
			Bolus	91840	134.6	11.0	70.8	193.2	18.9			
			Roots	28560	181.0	52.7	63.2	101.0	13.5			
			Understory veg.	54	9.0	.8	2.2	3.4	1.5			
Ohio, USA	Alnus glutinosa	4	Aboveground									
			Foliage	2600	82	5	28	50	8	Mn 0.78		Wittwer & Immel 1980
			Branches	5500	56	3	22	49	4	Mn 1.56		
			Stem	16300	43	4	26	15	5	Mn 0.43		
			Bark	4100	45	3	12	68	2	Mn 1.65		
			Total tree	28500	226	15	88	182	19	Mn 4.42		
England	Alnus incana	22	Leaves + Branches	28000	420	30	78	304	23	Na 4		Ovington 1962
			Trunks	83100	220	26	50	280	16	3		
			Understory	2100	50	4	22	46	5	1		
Washington, U.S.A.	Alnus rubra (high site)	?	Tree	15600	362	47	173					West et al. 1981 (prelim. data)
	Alnus rubra (poor site)	?	Understory	1300	24	2	23					
			Tree	126000	378	27	143					
			Understory	1400	25	2	23					
Washington, USA	Alnus rubra	33	Leaves	4100	100	5	43	42	8.4	Mn 4.0		Turner et al. 1976
			Branches	19400	20	2	4	77	6.8	1.0		
			Bark	23600	165	10	18	69	38.0	6		
			Trunks	128000	128	16	27	51	45.1	6		
			Roots	35200	176	4	7	123	12.4	5		
			Overstory									
			Total	210000	589	37	99	299	110.7	24		
			Understory	9500	103	7	132	95	16	1.4		

Table 4 Standing Crop Biomass & Nutrient Content

Location	Dom. Veg.	Age	Component	Biomass	kg/ha		P	K	Ca	Mg	Other	Reference
Washington, USA	<i>Alnus rubra</i> , high productivity	53	Foliage	9930	263	21	173					Bigger & Cole 1983
			Branches	9980	60	6	23					
			Bole	137000	287	41	151					
			Understory	1720	29	2.4	23					
			Forest floor	15000	327	20	30					
			Soil to 50 cm	144000	3603							
			Total	318000	4560							
Washington, USA	<i>Alnus rubra</i> , low productivity	53	Foliage	6060	145	9.3	64					Bigger and Cole 1983
			Branches	9270	67	4.7	21					
			Bole	111000	311	22	122					
			Understory	1900	32	2.4	23					
			Forest floor	14100	330	17	22					
			Soil to 50 cm	111900	3997							
			Total	302000	4590							
Connecticut	<i>Alnus rugosa</i>	16	Foliage	675	18							Voight & Steucek 1969
			Twigs	2150	20							
			Stems	14700	52							
			Coarse roots	4425	22							
			Fine roots	290	3							
			Nodules	12	.3							
			Total									
Korea	<i>Alnus sibirica</i>	12	Leaves	3460	46	6.4	29					Mun et al. 1977
			Branches	10800	61	5.0	11					
			Stems	31180	136	7.5	20					
			Roots	11355	77	3.0	63					
			Understory	4460	59	3.6	37					
			Total									
B.C., Canada	<i>Alnus sinuata</i>	5	Leaves	1750	44	6.9	15.0		19.7	3.3		Binkley 1982
			Stems	8910	57	13.6	21.0		20.3	3.6		
			Roots	2930	19	4.5	6.9		6.7	1.2		
			Total									
Alaska, USA	<i>Alnus tenuifolia</i>	5	Aboveground			9.7	39.9		58.9	6.8	Mn 0.1	Van Cleave and Viereck, 1972
			Roots			3.7	13.5		88.3	28.4	0.5	
			Aboveground			8.4	55.1		160.6	10.7	0.8	
			Roots			6.4	33.2		188.6	28.3	1.6	
			Aboveground			23.0	94.0		180.2	14.0	0.3	
			Roots			22.8	72.2		181.0	30.9	1.3	
			Total									
Japan	<i>Betula platyphylla</i>	Not Given	Leaves	2100	50.6	2.5	29.4		26.3	14.9		Tsutsumi 1971 and Kawahara and Tsutsumi 1972
			Branches	13900	58.4	5.4	16.7		82.0	15.3		
			Trunks	97800	156	11.7	38.1		293	64.5		
			Total									

Table 4 Standing Crop Biomass & Nutrient Content

Location	Dom. Veg.	Age	Component	Biomass	kg/ha		P	K	Ca	Mg	Other	Reference
					N							
U.S.S.R.	Betula	20	Foliage	1700								Cited in Rodin and and Basilevich 1967
			Woody	57000								
			Roots	30100							Ash 925	
			Total	89800	450							
U.S.S.R.	Betula	35	Foliage	5200								Cited in Rodin and Basilevich 1967
			Woody	164200								
			Roots	43900							Ash 1249	
			Total	213300	876							
Finland	Betula	40	Leaves	2900	70.2	5.6	29.0	31.2				Malkonen 1977
			Live Branches	8580	33.7	4.4	13.7	36.6				
			Dead Branches	250	0.7	<0.1	0.1	0.7				
			Bark	11400	54.0	4.7	44.8	69.7				
			Stemwood	67100	55.7	6.6	24.3	38.0				
			Below ground	24120								
			Roots>1cm		13.5	4.5	11.3	15.0				
			Roots<1cm		36.8	5.3	11.6	29.0				
			Stumps		4.8	0.6	2.4	2.5				
			Understory	2560	33.2	4.2	31.4	14.3				
U.S.S.R.	Betula	40	Foliage	3700								Smirnova and Gorodentseva 1958 (cited in Rodin and Basilevich 1967)
			Woody	203400								
			Roots	42800							Ash 1666	
			Total	249900	959							
U.K.	Betula	42	Foliage	1100								Ovington and Madgwick, 1959 (cited in Rodin and Basilevich, 1967)
			Woody	67500								
			Roots	25800							Ash 426	
			Total	94400	253							
Ohio, USA	Betula nigra	4	Aboveground									Wittwer & Immel 1980
			Foliage	1800	40	3	15	36	5		Mn 0.90	
			Branches	8800	53	3	21	62	5		Mn .64	
			Stem	20500	44	10	30	21	10		Mn 0.62	
			Bark	1000	9	1	2	17	1		Mn .16	
			Total tree	32100	146	17	58	136	21		Mn 2.32	
Alaska, USA	Betula papyrif.	50	Overstory:									Van Cleave in Cole & Rapp 1980
			Foliage Total	2362.8	51.1	5.2	22.8	14.9	8.2			
			Branches	11025.2	39.8	4.9	17.1	37.9	5.7			
			Boles	83954.9	130.0	9.4	64.3	110.9	24.2			
			Roots	44297	131.1	15.4	43.3	99.3	20.6			
			Understory veg.	95	1.0	15.5	44.8	134.2	23.5			

Table 4 Standing Crop Biomass & Nutrient Content

Location	Dom. Veg.	Age	Component	Biomass	kg/ha		P	K	Ca	Mg	Other	Reference
					N							
England	<i>Betula verrucosa</i>	24	Leaves	2400	47	3	28	32	5	Na	1	Ovington and Madgwick 1959 (cited in Ovington 1962)
			Branches	11800	68	5	21	69	6		1	
			Trunks	48000	73	6	29	132	13		1	
			Roots	16900	89	5	15	79	4		1	
England	<i>Betula verrucosa</i>	22	Leaves	17700	178	22	45	192	17	Na	1	Ovington 1962
			+Branches Trunks Understory	43100 2200	62 24	8 3	17 14	120 15	7 2		1	
England	<i>Betula verrucosa</i>	55	Leaves	2500	78	4	43	42	7	Na	1	Ovington and Madgwick 1959 (cited in Ovington 1962)
			Branches	27000	168	12	46	180	13		3	
			Trunks	134500	145	11	65	275	26		2	
			Roots	49800	152	7	46	154	14		4	
U.S.S.R.	Bogwhortleberry forest	200	Aboveground	63000	210	15	80	120	30			Rodin & Bazilevich 1967
U.S.S.R.	<i>Carpinus, Fagus</i>	46	Foliage	6400								After Dzents-Litovskaya 1960 (cited in Rodin & Basilevich 1967)
			Woody	216300								
			Roots	57600								
			Total	260300						Ash 3844		
U.K.	<i>Castanea sativa</i>	39-47	Aboveground + thinning	176000	245	15	85	205	40			Ovington 1962
			Leaves	8200	65	6	37	41	7	Na	1	
			+Branches	108400	116	6	31	106	20		2	
			Trunks	1200	15	2	9	7	3		1	
Japan	<i>Chamaecyparis</i>	28	Stand	143000	391	44	191	619	188			Harada et al. 1969
Kyoto, Japan	<i>Chamaecyparis</i>		Stem	84700	87.2	5.42	49.1	134.7	29.6			Iwatsubo 1976
			Branch	13500	40.1	2.58	17.4	62.7	6.2			
			New Fol.	2000	21.8	1.52	11.1	19.0	3.4			
			Old Fol.	8000	76.4	4.53	29.6	80.6	14.7			
Japan	<i>Cryptomeria japonica</i>	24	Roots	30100	45.5	2.30	17.3	49.7	10.2			
			Leaves	19900	243	25.1	99.5	175	47.8			Tsutsumi 1971
			Branches	7600	22	2.1	7.6	45.6	3.8			and Kawahara
			Trunks	117000	117	9.4	105	129	23.4			and Tsutsumi 1972

Table 4 Standing Crop Biomass & Nutrient Content

Location	Dom. Veg.	Age	Component	Biomass	kg/ha		P	K	Ca	Mg	Other	Reference
					N							
Japan	Cryptomeria	28	Stand	158700	441	44	269	857	185			Harada et al., 1969
Japan	Cryptomeria japonica	25	Leaves Branches Trunks	27400 10600 76000	282 20 84	25.2 2.2 8.7	159 8.5 76.0	189 19 106	84.9 10.6 22.8			Tsutsumi 1971 and Kawahara and Tsutsumi 1972
Australia	Eucalyptus regnans	27	Leaves Branches Trunks Understory Fine roots (0-12.5cm)	8100 71200 713100 38700 3500		1.81 3.9 10.1 1.7 3.3						Ashton 1976
Stradbroke Is. Qld., Australia	Eucalyptus	?	Stemwood Stem bark Live branches dead branches current twigs + leaves root crown top root lateral roots dead standing wood+bark	51880 6629 29870 5993 11590 21740 12140 28040 10470	103 18 24 17 69 40 18 96	2.6 .4 1.6 3.0 2.8 1.1 .5 5.9	5 71 32 1 30 2 1 29	55 75 61 13 60 19 15 37	2.3 8.4 6.6 3.2 36.1 .7 2.0 12.9	Na Na Na Na Na	69 14 19 4 27 8 6 20	Westman & Rogers 1977a
Australia	Eucalyptus sieberi	27	Leaves Branches Trunks Understory Fine roots (0-12.5cm)	12100 67000 804100 45300 3800		1.0 1.6 10.4 0.6 3.0						Ashton 1976
SW Australia	Eucalyptus diversicolor	36	wood bark leaves branches dead wood fruit total tree understory	183800 20000 4500 14900 1800 225000 10300	189 60	18 2	225 39	698 39	144 7	S Na Na	18 61 6 6	Mingston, Turbon, & Dimmock 1979
	Eucalyptus diversicolor- E. Calophylla	All	wood bark leaves branches dead wood fruit total tree understory	207900 35700 8900 31100 500 284000 1170	333 11	26 .4	389 9	1020 12	293 3	S Na S Na	33 114 2 1	

Table 4 Standing Crop Biomass & Nutrient Content

Location	Dom. Veg.	Age	Component	Biomass	kg/ha		P	K	Ca	Mg	Other	Reference
					N							
Japan	Evergreen broad-leaved	Not Given	Leaves	5000	78.5	5.1	44.0	26.0	17.5			Tsutsumi 1971 and Kawahara and Tsutsumi 1972
			Branches	23000	87.4	16.3	66.7	87.5	25.3			
			Trunks	86000	163	30.1	138	146	51.6			
Sweden	Fagus	90	Current twigs, leaves	4000	100	6.2	23	20	6.8	Si 1.3 Na 1.6 Fe 0.6 Mn 6.6 S 4.4		Nihigard 1972
		Branches	99000	660	55.2	228	381	40.9	Si 12.2 Na 13.4 Fe 9.4 Mn 59.8 S 34.9			
		Bark	9000	80	4.7	19	90	5.5	Si 2.9 Na 1.0 Fe 1.8 Mn 9.4 S 4.9			
		Trunks	212000	210	17.7	182	111	51.5	Si 4.7 Na 16.1 Fe 3.6 Mn 34.9 S 23.8			
		Stumps + large roots	37000	70	5.7	39	21	7.2	Si 4.1 Na 2.7 Fe 5.2 Mn 5.7 S 7.7			
		Medium roots	8000	40	5.2	21	12	2.7	Si 2.2 Na 2.3 Fe 2.0 Mn 2.9 S 3.3			
		Fine roots	6000	40	4.7	19	9	3.6	Si 5.2 Na 1.5 Fe 6.9 Mn 2.1 S 3.5			
		Total	375000	1210	100	539	645	118	Si 32.6 Na 38.7 Fe 26.9 Mn 126 S 82.7			

Table 4 Standing Crop Biomass & Nutrient Content

Location	Dom. Veg.	Age	Component	Biomass	kg/ha					Other	Reference
					N	P	K	Ca	Mg		
Germany	Fagus sylvatica	120	Aboveground	370000	1608						Rodin & Bazilevich 1967
Sweden	Fagus sylvatica	90	Stand	375000	1060	84	460	603	105		Nihlgard 1972
Moravia Czechoslovakia	Flood-Plain Forest Stand										Klino 1975
	Trees		aboveground parts		1.5	83	577	1.9	126	C 189.7 Ash 6.1	
	Shrubs		aboveground parts		55	8	26	31	9	C 2.2 Ash 234	
	Herbs		aboveground parts		22	4	47	21	5	C 657 Ash 187	
	Trees		under ground parts		189	31	68	226	48	C 10.5 Ash 1.3	
	Shrubs		under ground parts		15	2	6	8	3	C 787 Ash 63	
	Herbs		under ground parts		6	1	10	6	1	C 254 Ash 72	
Ohio, USA	Fraxinus pennsylvanica	4	Aboveground								Wittwer & Immel 1980
	Foliage		2100	30	8	36	27		4	Mn 0.08	
	Branches		4600	30	3	16	25		4	Mn .04	
	Bark		800	6	2	3	10		1	Mn .02	
	Stem		9700	24	5	20	8		4	Mn 0.10	
	Total tree		17200	90	18	75	70		13	Mn .24	
	Sprouts			16.6	1.4	8.6	11.8		2.5		
	Herbs			8.2	.7	13.0	4.4		1.5		
	Vines			3.2	.3	2.1	2.6		.6		
	Seedlings			1.2	.1	.8	.7		.2		
N. Carolina, USA	Hardwood										Boring et al. 1979
England	Larix decidua	46	Leaves +Branches Trunks	43600	357	31	110	100	14	Na 4	Ovington 1962
	Understory		145800	108	13	32	72		21	3	
			4600	60	10	74	26		8	5	
U.K.	Larix decidua	39- 47	Aboveground + thinning	275000	528	52	161	214	47		Ovington 1962
Japan	Larix leptolepis	28	Leaves Branches Trunks	4500 13200 82100	88.6 43.2 98.5	6.5 5.4 15.6	36.5 43.2 132	17.2 37.7 52.5	8.0 8.2 23.8		Tsutsumi 1971 and Kawahara and Tsutsumi 1972

Table 4 Standing Crop Biomass & Nutrient Content

Location	Dom. Veg.	Age	Component	Biomass	kg/ha			K	Ca	Mg	Other	Reference
					N	P						
Tennessee, USA	Liriodendron Quercus, Carya	30- 80	Overstory:									Harris-Henderson in Cole & Rapp 1980
			Foliage Total	5100	78.0	6.0	45.0	75.0	21.0			
			Branches	21000	54.0	7.0	37.0	155.0	13.0			
			Boles	83000	135.0	8.0	90.0	307.0	25.0			
Tennessee, USA	Liriodendron	50	Roots	31000	122.0	22.0	132.0	211.0	19.0			Harris-Edwards in Cole & Rapp 1980
			Understory									
			veg.	8800	23.8	5.7	32.4	115.2				
			Foliage Total	3200	53.9	6.3	52.3	35.2				
Japan	Mixed hardwoods (ridge-top)	Not Given	Branches	27100	78.6	30.6	46.1	143.7				Katagiri and Tsutsumi 1975
			Boles	94400	172.0	9.7	74.8	276.8				
			Roots	36000	122.7	18.5	111.5	150.8				
			Understory									
Japan	Mixed	Not Given	Leaves	3000	60	3.2	26.5	33	8.4			Katagiri et al. 1978
			Trunks	19000	85	8.0	37.0	125	15.0			
			Not Given	56000	100	7.3	59.0	250	22.5			
			Leaves	3000	60	3.5	26	35	9			
Japan	Mixed broad -Lower slope	Not Given	Branches	103000	465	43.0	200	680	80			Katagiri & Tsutsumi 1978
			Trunks	157000	280	20.0	165	700	62			
			Foliage	7310	108.2	5.9	43.2	40.2	12.3			
			Branch	55300	276.4	23.2	165.8	254.2	56.9			
Japan	Mixed broad -Upper slope	Not Given	Stem	325200	520.3	29.3	552.8	601.6	84.5			Iwatsubo 1976
			Small trees	4900	23.6	1.6	9.6	15.4	5.1			
			Foliage	4230	77	4.23	34.7	43.6	11.0			
			Branches	101990	459	42.84	198.9	673.1	79.6			
Kyoto, Japan	Mixed broad	Not Given	Stem	170710	307	22.19	179.3	768.2	68.3			West et al. 1981 (prelim. data)
			Foliage	3260	60	3.26	26.7	33.6	8.5			
			Branches	18690	84	7.86	36.5	123.9	14.6			
			Stem	56470	102	7.34	59.3	254.1	22.6			
Tennessee, USA	Mixed hardwood	?	Stem	59600	72.3	4.78	65.9	146.1	52.6			West et al. 1981 (prelim. data)
			Branch	23100	80.6	5.75	59.2	78.1	19.7			
			New Fol.	3100	45.6	2.04	37.4	19.8	9.7			
			Old Fol.	2600	31.6	1.51	16.5	18.1	5.6			
Tennessee, USA	Mixed hardwood	?	Roots	38100	82.3	4.52	71.4	81.4	33.5			West et al. 1981 (prelim. data)
			Trees									
			Foliage	3480	60	4	50	40				
			Branches	35950	120	11	120	390				
Tennessee, USA	Mixed hardwood	?	Stems	132380	240	18	180	890				West et al. 1981 (prelim. data)
			Understory									
			Foliage	930	10	1	10	10				
			Stems	14980	70	5	30	150				

Table 4 Standing Crop Biomass & Nutrient Content

Location	Dom. Veg.	Age	Component	Biomass	kg/ha			kg			Other	Reference
					N	P	K	Ca	Mg			
U.S.S.R.	Picea	110	Foliage	14900								Parshevnikov, 1957, 1962
			Woody	182300								(cited in Rodin and Basilevich, 1967)
			Total aboveground		820	50	270	860	180		Ash 2494	
			Roots	76500								
			Total	273800	1327							
U.S.S.R.	Picea	120	Foliage	4500								Ebermayer 1876
			Woody	35500								(cited in Rodin and Basilevich 1967)
			Roots	11300							Ash 293	
			Total	51300	174							
U.S.S.R.	Picea	125	Foliage	11500								Cited in Rodin and Basilevich 1967
			Woody	121300								
			Roots	40700								
			Total	173500	447						Ash 1013	
U.S.S.R.	Picea	130	Foliage	12300								Parshevnikov, 1957, 1962
			Woody	118900								(cited in Rodin and Basilevich, 1967)
			Total aboveground		470	30	160	595	80		Ash 1776	
			Roots	65700								
			Total	186900	882							
U.S.S.R.	Picea	200	Foliage	21100								Marchenko and Karlov 1961, 1962 (cited in Rodin and Basilevich 1967)
			Woody	234600								
			Roots	85100							Ash 1988	
			Total	340800	1977							
U.S.S.R.	Picea	45-55	Foliage	6100								Remezov et al. 1959
			Woody	191900								(cited in Rodin and Basilevich 1967)
			Roots	32900							Ash 1994	
			Total	230900	819							
Sweden	Picea abies on sphagnum	60-70	Wood	117700	77.7	9.4	29.4	78.8	11.8			Holmen 1964
			Bark	10000	53.9	7.0	20.7	128.2	8.3			
			Live branches	29300	170.2	19.1	49.9	161.4	18.2			
			Needles	15900	210.1	33.6	65.3	128.9	22.3			
			Dead branches	4700	22.0	1.3	2.3	23.9	.6			
New York, USA	Picea abies	33	Stand	61411	399	59	44	376	19			Fornes et al. 1970

Table 4 Standing Crop Biomass & Nutrient Content

Location	Dom. Veg.	Age	Component	Biomass	kg/ha		K	Ca	Mg	Other	Reference
					N	P					
Sweden	Picea abies	55	Aboveground	308000	770	87	437	459			Nykvist 1974
		120		308000	586	68	328				
		53		138000	330	44	152	211			
		59		114000	226	32	142	282			
		100		181000	369	35	160	454			
		139		149000	295	35	159	374			
		65		178000	534	70	167	521			
England	Picea abies	47	Leaves +Branches Trunks	31900	226	26	117	105	20	Na 3	Ovington 1962
				107900	105	11	44	107	19	2	
Solling, W. Germany	Picea abies	85	Foliage	18000	270	28.8	126	72	9		Ulrich et al. 1974
			Branches	28000	168	33.6	168	56	19.6		
			Stem wood	194000	175	27.2	175	194	38.8		
			Bark	18000	180	23.4	72	162	16.2		
			Stump + lge roots	70000	420	84	420	140	49		
			fine roots	2000	12	2.4	12	4	1.4		
Sweden	Picea abies	55	Leaves	18000	220	21.8	122	84	9.6	Si 12.3 Na 4.9 Fe 2.0 Mn 40.5 S 20.7	Nihlgard 1972
			Current Twigs	3300	50	6.5	31	6	2.5	Si 0.1 Na 0.3 Fe 0.2 Mn 2.1 S 2.6	
			Branches	25000	230	30.2	112	86	18.2	Si 3.8 Na 8.4 Fe 7.0 Mn 17.3 S 20.0	
			Bark	22000	100	13.6	69	168	21.4	Si 3.1 Na 3.5 Fe 3.1 Mn 29.0 S 11.3	
			Trunks	240000	170	14.9	103	115	17.5	Si 7.4 Na 20.4 Fe 2.7 Mn 54.0 S 57.6	
			Stumps+ large roots	52000	50	2.4	51	23	7.0	Si 1.3 Na 1.8 Fe 3.5 Mn 10.0 S 10.0	
			Medium roots	4500	20	1.7	8	14	1.9	Si 0.1 Na 0.5 Fe 0.7 Mn 2.7 S 2.6	

Table 4 Standing Crop Biomass & Nutrient Content

Location	Dom. Veg.	Age	Component	Biomass	kg/ha		P	K	Ca	Mg	Other	Reference
				2000	20	N	1.6	6	8	1.6	Si 0.4 Na 1.4 Fe 1.2 Mn 2.3 S 1.9 Si 28.5 Na 41.2 Fe 20.4 Mn 158 S 127	
			Fine roots									
			Total	367000	860		92.7	502	504	79.7		
Sweden	Picea abies	55	Needles Branches Wood Bark Roots	18000 28000 24000 22000 59000	220 280 170 100 90		22 38 15 14 6	122 143 103 69 65	84 92 115 168 45	10 21 18 21 10		Nihlgard 1972
England	Picea abies	20	Leaves +Branches Trunks	61100 157200	599 260		65 34	301 136	167 190	48 34	Na 12 2	Ovington 1962
Sweden	Picea abies	13	Stem wood bark Branches Needles Stem wood bark Branches Needles Roots >5mm Roots <5mm	8520 1720 7510 8620 40060 6400 12860 13400 11070 4740								Tamm 1975
Finland	Picea abies	70	Aboveground	160000	343			136	368			Malkonen, 1973
U.K.	Picea abies	47	Stand, litter & understory	165000	691		56	191	277			Ovington 1962
Sweden	Picea abies	52	Leaves Branches Trunks	10800 15600 105800	128 74 109		20 9 12	49 27 65	50 44 108	9 8 18		Tamm and Carbonnier 1961 (cited in Ovington 1962)

Table 4 Standing Crop Biomass & Nutrient Content

Location	Dom. Veg.	Age	Component	Biomass	kg/ha		K	Ca	Mg	Other	Reference
					N	P					
Germany	Picea abies	34	Overstory:								Ulrich in Cole & Rapp 1980
			Foliage Total	18870	247.8	29.6	132.2	60.5	17.9		
			Branches	18730	99.4	22.8	111.9	35.3	21.2		
			Boles	105100	102.2	6.3	105.1	195.4	22.5		
			Roots	34560							
England	Picea abies	47	Leaves + Branches	80300	573	64	166	309	50	Na 9	Ovington 1962
			Trunks	182400	132	18	60	198	35	3	
Sweden	Picea abies no thinning no thinning	59	Total	114800	226	32	142	282			Tamm 1969
		50	Total	283500	842	80	442	463			
		85	Total	381700	722	78	330	541			
Sweden	Picea abies	58	Leaves	9100	91	15	56	76			Tamm and Carbonnier 1961 (cited in Ovington 1962)
			Branches Trunks	14300 85200	60 63	8 8	29 52	63 120			
Sweden	Picea abies	60	Overstory:								Nihlgard 1972
			Foliage Total	18000	220.0	21.8	122.0	84.0	9.6		
			Branches	25000	230.0	30.2	112.0	86.0	18.2		
			Boles	262000	270.0	28.5	172.0	283.0	38.9		
			Roots	59000	90.0	5.7	65.0	45.0	10.5		
Sweden	Picea abies	65- 132	Understory veg.		.001	.01	.02	.1	.02	10	Nykqvist
			Stem wood	127300	74	5.2	37.1	93	10.2	Na 1.27	
			bark	11100	38	4.7	20.8	119	6.6	Mn 22.5	
			Needles	14900	155	14.4	64.6	119	14.9	Na 1.20	
			Shoots	500	5	.8	3.8	2	.7	Mn 35.7	
			Branches <5mm	7800	50	5.3	16.9	33	7.0	Na .86	
			Branches 5-20	9600	28	3.0	10.8	43	5.1	Mn 5.0	
			Branches >20mm	8300	14	1.3	5.4	43	2.9	Na 6.2	
			Dead Br. <5	300	1	.1	.1	1	.1	Mn 5.0	
			5-20	1400	3	.2	.1	3	.1	Na .01	
			>20mm	100	.2	.01	.01	.3	.01	Mn .03	
			Roots L layer	3100	6	.8	4.1	9	1.1	Na .04	
			F 5-20	100	.3	.03	.1	.2	.03	Mn .18	
			2-5	300	2	.2	.6	1	.2	Na .03	
			>2mm	500	4	.4	1.2	1	.3	Mn .01	
			H >20mm	1400	4	.4	1.8	4	.5	Na .02	
										Mn .08	
										Na .5	

Table 4 Standing Crop Biomass & Nutrient Content

Location	Dom. Veg.	Age	Component	Biomass	kg/ha	N	P	K	Ca	Mg	Other	Reference
			5-20	2000	9	.9	3.6	6		.9	Na .18 Mn 1.0	
			2-5	1100	6	.6	2.1	3		.7	Na .11 Mn .7	
			<2	800	6	.5	1.5	2		.5	Na .16 Mn .6	
			Min. Soil	1900	5	.6	2.5	5		.6	Na .14 Mn .5	
			Vacc. myrt.	185	1.95	.17	.92	.96		.17	Na tr Mn .57	
			Vacc. vitis	4	.04	.003	.02	.02		.01	Na tr Mn .01	
			Deschampsia	60	1.05	.11	1.43	.13		.06	Na tr Mn .05	
			Luzula pil.	3	.06	.01	.11	.02		.01	Na tr Mn .01	
			Field layer	270	3.4	.33	2.94	1.31		.29	Na .01 Mn .68	
			Ground layer	520	7.8	1.15	6.65	1.39		.54	Na .08 Mn .39	
U.S.S.R.	Picea abies	72 83 110	Total Total Total	291000 358000 274000	564 847 1327							Rodin & Bazilevich 1967
U.S.S.R.	Picea abies	45	Overstory: Foliage Total Branches Boles Roots Understory veg.	9800 12100 56300 15800 1606	101.9 55.7 123.9 63.2 22.1	11.8 4.8 11.2 7.9 3.1	50.0 15.7 39.4 23.7 12.0	95.1 44.8 101.3 44.2 10.5		13.7 6.0 11.2 6.3 2.0		Kazimirov & Morozova 1973
Germany	Picea abies	87	Overstory: Foliage Total Branches Boles Roots	17880 28210 198400 71720	228.0 242.7 258.4 71720	13.8 17.3 7.9 7.9	118.8 183.1 99.3 99.3	70.3 74.8 267.6 267.6		5.6 19.7 30.7 30.7		Ulrich in Cole & Rapp 1980
U.K.	Picea abies	39- 47	Aboveground + thinning	350000	536	59	246	421		76		Ovington 1962

Table 4 Standing Crop Biomass & Nutrient Content

Location	Dom. Veg.	Age	Component	Biomass	kg/ha		P	K	Ca	Mg	Other	Reference
					N							
Germany	Picea abies	115	Overstory: Foliage Total Branches Boles Roots	12660 246300 195700 74930	161.4 212.0 255.0	13.3 15.1 36.9	84.1 160.0 98.0	49.7 65.3 264.1	40.0 17.2 30.3			Ulrich in Cole & Rapp 1980
Czechoslovakia	Picea abies	100	Aboveground		830	109	317	455	30			Rodin & Bazilevich 1967
U.S.S.R.	Picea abies	120 125 130	Total Total Total	51000 174000 197000	174 447 882							Rodin & Bazilevich 1967
U.S.S.R.	Picea abies	200	Total	336000	1915	67	449	732	142		S 91 Fe 76 Mn 28 S 24 Fe 16 Mn 27	Marchenko & Karlov 1962
	Picea, Betula	80- 200	Total	129000	619	33	133	243	74			
Sweden	Picea abies		Total, above ground	10660	52	7	32	65	6		Mn 13	Tamm 1974
U.S.S.R.	Picea forest	93	Aboveground	468	85	278	552	90				Rodin & Bazilevich 1967
Minnesota, USA	Picea glauca	40	Stand	184800	449	64	204	809	46			Alban et al., 1978
Minnesota, USA	Picea glauca	41	Overstory Foliage Live branch Dead branch Bark Bolewood Root+stump Understory Herbs Shrub leaves Shrub stems	11700 17000 14200 12400 92000 32000 10 0 0	130 70 31 45 56 43	18.3 12.6 3.0 7.5 4.3 7.0	64 52 7 26 27 25	140 115 93 188 115 96	11.0 12.1 4.2 8.9 6.8 6.0			Perala & Alban, 1979
					.2	.04	.3	.1	.03			
					0	0	0	0	0	0		
					0	0	0	0	0	0		

Table 4 Standing Crop Biomass & Nutrient Content

Location	Dom. Veg.	Age	Component	Biomass	kg/ha		P	K	Ca	Mg	Other	Reference
					N							
Prince George, Picea glauca B.C., Canada	110- 350		Total		316.4	47.8	135.3	531.7	211.7			Kimmins 1974
			Wood	115897	59.8	3.6	57.3	86.2	9.3			
			Bark	22929	57.4	8.3	27.3	206.3	5.3			
			Lge. branches	12369	21.7	2.1	6.1	59.9	.8			
			Sm. branches	7231	18.1	2.3	5.9	38.0	.5			
			Twigs	4016	25.5	3.9	2.0	14.8	.3			
			Foliage	6894	61.5	9.5	3.5	25.5	.6			
			Twigs & foliage	10909	86.6	13.4	5.5	40.3	.9			
			Crown	30511	126.4	17.8	17.5	138.2	2.2			
			Bole	138827	117.2	11.9	84.6	292.5	14.6			
Quebec, Canada	65		Roots		72.8	18.1	33.2	101.0	7.9			Weetman & Webber 1972
			Total aboveground		243.7	29.5	99.7	430.7	25.0			
			Foliage	8280	65	16	30	73	9			
			Branches	10300	31		13	41				
			Wood	76900	45	26	20	112	18			
			Bark	11600	26		21	51				
			Overstory:									
			Foliage Total	5012	21.0	2.8	9.8	3.5	2.9			
			Branches	3590	7.4	1.1	3.9	1.8	1.8			
			Boles	7995	11.5	1.6	10.3	24.2	2.2			
Alaska, USA	51		Roots	12457	18.5	2.9	13.7	21.4	3.1			Van Cleave in Cole & Rapp 1980
			Understory veg.	8639	66.7	7.6	20.0	31.7	11.3			
			Overstory:									
			Foliage Total	5310	26.4	3.6	13.7	53.3	2.6			
			Branches	4691	19.2	1.7	5.4	17.9	3.1			
			Boles	14017	49.0	8.9	12.2	48.7	4.8			
			Roots	10401	39.5	5.1	41.2	88.7	10.4			
			Understory veg.	6283	50.8	5.2	15.3	22.0	6.4			
			Overstory:									
			Foliage Total	14196	70.8	8.5	17.6	163.3	15.9			
	130		Branches	12947	49.0	6.1	6.2	71.0	10.7			
			Boles	86046	95.1	14.3	51.8	390.7	33.4			
			Roots	51697	70.8	7.6	24.5	97.5	11.4			
			Understory veg.	7598	46.7	6.9	24.4	28.4	7.4			

Table 4 Standing Crop Biomass & Nutrient Content

Location	Dom. Veg.	Age	Component	Biomass	kg/ha			K	Ca	Mg	Other	Reference
		up to			N	P						
B.C. Canada	Picea/Pinus forest	350	Aboveground	213000	324	42	150	537	31			Kimmins 1974
N. Carolina, USA	Picea, Abies	50	Aboveground	180000		37	177	354	72			Weaver 1973, 1975
U.K.	Pinus (plantation)	20	Aboveground	52000	290	30	130	110	25			Ovington 1962
Sweden	Pinus abies	55	Stand	367000	770	87	437	459	69			Nihlgard 1972
E. Canada	Pinus banksiana	20	Total	13207	32.9	3.0	15.5	19.4	3.1			Morrison, 1973
		20	Total	7354	18.9	1.7	8.9	11.1	1.8			
		20	Total	16002	38.8	3.5	18.3	23.1	3.7			
		20	Total	6865	15.8	1.4	7.5	9.6	1.5			
		30	Total	99212	195.0	16.3	94.7	126.4	19.8			
		30	Total	63434	113.2	9.2	55.7	76.3	11.8			
		30	Total	88498	184.8	15.8	89.0	116.9	18.4			
		30	Total	61000	119.0	9.9	57.9	77.4	12.1			
		65	Total	105783	161.1	12.5	81.0	115.6	17.5			
		65	Total	53989	84.9	6.6	42.5	60.2	9.2			
		65	Total	76046	121.2	9.5	60.6	85.5	13.0			
		65	Total	43637	71.3	5.6	35.5	49.8	7.6			
Ontario	Pinus banksiana	45	Stand	124482	182	22	140	150	26			Morrison & Foster 1977
Minnesota, USA	Pinus banksiana	40	Stand	175300	296	30	119	241	46			Alban et al, 1978
Ontario, Canada	Pinus banksiana	65	Foliage	4345	50	6	14	12	3			Morrison & Foster, 1979
			Cones	2910	5	1	1	1	<1			
			Branches	16267	43	3	24	27	4			
			Stemwood	83451	65	3	43	57	10			
			Stembark	6696	17	1	7	30	2			
			Roots	23256	24	3	15	28	6			
			Ground veg.	310	4	<1	2	1	<1			
Minnesota, USA	Pinus banksiana		Trees-shallow	198	12	55	138	27	27			Green and Grigal 1979 (in White and Harvey, 1979)
			-deep	310	26	127	258	48	48			
			Understory									
			-shallow	54	4	12	28	5	5			
			-deep	36	3	19	36	4	4			

Table 4 Standing Crop Biomass & Nutrient Content

Location	Dom. Veg.	Age	Component	Biomass	kg/ha				Reference			
					N	P	K	Ca	Mg	Other		
Japan	Pinus densiflora	Not Given	Leaves Branches Trunks	8500 15500 93700	86.1 46.8 65.6	8.0 6.8 9.4	42.9 71.9 93.7	46.8 90.7 244	21.6 21.2 169		Tsutsumi 1971 and Kawahara and Tsutsumi 1972	
Tennessee, USA	Pinus echinata	30	Overstory: Foliage Total Branches Boles Roots	4600 27000 89000 34000	51.0 64.0 100.0 117.0	4.0 7.0 7.0 21.0	36.0 29.0 60.0 128.0	43.0 100.0 164.0 187.0	12.0 11.0 17.0		Harris in Cole & Rapp 1980	
Florida, USA	Pinus elliotii		Bole Branches Foliage Understory	90140 7390 4530 5300	99.1 17.0 36.2 23.6	9.0 1.5 1.4 1.7	18.0 4.4 10.9 5.2	153.0 21.4 10.9 22.4	18.0 3.0 5.4 5.1		West et al., 1981 (prelim. data)	
Florida, USA	Pinus elliotii		Bole Branches Foliage Understory	93,030 7540 5230 5700	102.0 17.3 41.8 25.0	9.3 1.5 1.6 1.7	18.6 4.5 12.5 5.1	158.0 21.9 12.6 19.3	18.6 3.0 6.3 5.8		West et al., 1981 (prelim. data)	
England	Pinus nigra	46	Leaves +Branches Trunks Understory	30200 212000 6800	207 229 87	17 14 7	93 102 156	75 115 55	14 39 10	Na 2 3	Ovington 1962	
Scotland	Pinus nigra	40	Foliage Live Branch Dead Branch Stem Wood Bark Roots	11300 16700 5300 85000 15000 33300	175 57 9 61 53 83	15 5 1 4 5 13	77 30 2 32 18 42	38 51 16 42 32 20	12 10 3 12 8 13	Na 6 Na 3 Na 2 Na 4 Na 5 Na 5	Miller & Miller 1976 Miller, Miller, and Pauline 1976	
Scotland	Pinus nigra	35	Total	149600	256	51	180	153	68		Craig and Miller 1967 (cited in Foster and Morrison 1976)	
England	Pinus nigra	64	Aboveground	119000	205	23	100	202	35		Ovington 1962	
U.K.	Pinus nigra	18	Needles Branches Bark Wood Total	3000 6100 4700 10800 24650	30.0 20.9 17.1 9.1 77.1	4.9 3.1 2.5 1.0 11.5	18.2 15.0 8.0 5.9 47.2	18.2 26.8 15.0 9.6 69.7	3.1 5.0 3.8 2.0 13.9		Wright and Will 1958 Note: some totals do not add up precisely due to conversion of pound/acre to kg/ha.	
		28	Needles Branches Bark Wood Total	4600 10400 12300 38000 65400	31.1 22.5 22.5 21.4 97.6	4.9 3.0 3.5 1.6 3.1	49.2 18.8 17.7 15.0 76.1	22.5 48.2 25.7 21.4 117.9	3.8 6.9 5.1 4.0 19.7			
		48	Needles Branches Bark Wood Total	5360 10720 20000 70000 107200	49.3 33.8 44.5 49.3 176.9	6.8 4.3 6.2 4.1 21.3	34.3 27.8 29.5 35.9 127.6	25.7 48.2 30.0 46.1 50.1	6.5 9.1 9.5 11.3 36.5			

Table 4 Standing Crop Biomass & Nutrient Content

Location	Dom. Veg.	Age	Component	Biomass	kg/ha			K	Ca	Mg	Other	Reference
						N	P					
Scotland	Pinus nigra	48	Aboveground	112085	185	22	133	157	38			Wright & Will 1958
U.K.	Pinus nigra	47	Stand, litter + understorey	176000	556	43	325	229				Ovington 1962
England	Pinus nigra	35	Aboveground	200000	586	75	207	230	93			Ovington 1962
U.K.	Pinus nigra	39-47	Aboveground + thinning	426000	635	43	284	290	87			Ovington 1962
Arizona, USA	Pinus ponderosa	49	Leaves Branches Trunks Roots Understorey	10620 20150 121000 38000 100	111 65 145 93 1							Klemmedson, 1975
Arizona, USA	Pinus ponderosa	50	Leaves Branches Trunks Roots	10000 38000 183000 15000	109 95 194 37							Basalt Parent Material
		50	Leaves Branches Trunks	21000 43000 214000	224 112 220							Andesite Parent Material
		50	Leaves Branches Trunks Roots	25000 18000 53000 261000	51 181 134 240							Rhyolite Parent Material
		50	Leaves Branches Trunks Roots	16000 8000 44000 168000	37 83 103 156							Limestone Parent Material
Japan	Pinus pumila		New fol. Old fol. Branches Stems	6810 14800 24100 39100	89.2 194 123 102	12 18.4 18.1 13.3	39.4 48.5 50.1 53.6	7.2 35.8 46.3 44.2	7.3 15.2 25.3 32.8			Tsutsumi et al. 1968
New Zealand	Pinus radiata	26	Total Slash Logs Roots	252200 20175 201753 28021	258 93 173 34	41 10 18 13	252 66 158 28	157 25 105 28				Will 1968 (cited in Foster & Morrison 1976)

Table 4 Standing Crop Biomass & Nutrient Content

Location	Dom. Veg.	Age	Component	kg/ha					Mg	Other	Reference
				Biomass	N	P	K	Ca			
New Zealand	Pinus radiata	35	Aboveground	362000	230	32	283	188			Orman & Will 1960 (cited in Foster and Morrison, 1976)
New Zealand	Pinus radiata	26	Aboveground	222500	221	28	225	130			
New Zealand	Pinus radiata	10	Stem wood	49590							Madgwick et al. 1977
			bark	4780							
			Live branches	11380							
			Dead branches	50							
			Cones	210							
			1 yr. needles	4730							
			2 yr. needles	1070							
			3 yr. needles	50							
			4 yr. needles	0							
			5 yr. needles	0							
			Stem wood	243500							
			bark	27360							
New Zealand	Pinus radiata	22	Live branches	27360							Will 1964 (cited in Foster & Morrison 1976)
			Dead branches	4600							
			Cones	3210							
			1 yr. needles	4020							
			2 yr. needles	3070							
			3 yr. needles	1910							
			4 yr. needles	260							
			5 yr. needles	10							
			Aboveground	305600	320	40	325	188			
New Zealand	Pinus radiata (-lupins)	4	Foliage	3570	42.8						Madgwick et al. 1977
			Branches	2470	7.3						
			Stem wood	5240	5.8						
			bark	820	4.6						
			Dead twigs	110	1.0						
			Foliage	2100	32.4						
			Branches	1490	6.3						
			Stem wood	2090	3.2						
			bark	370	2.8						
			Dead twigs	60	.4						
			Lupins	9200	83.1						

Table 4 Standing Crop Biomass & Nutrient Content

Location	Dom. Veg.	Age	Component	Biomass	kg/ha		P	K	Ca	Mg	Other	Reference
					N							
New York, USA	Pinus resinosa	32	Stand	142777	307	33	33	83	295	28		Fornes et al, 1970
Minnesota, USA	Pinus resinosa	40	Stand	243400	421	50	205	335	72			Alban et al, 1978
Minnesota, USA	Pinus resinosa	41	Overstory									Perala & Alban, 1979
			Foliage	10600	110	12.5	59	33		11.5		
			Live branch	9800	22	3.9	18	30		5.1		
			Dead branch	6900	15	.6	2	24		2.3		
			Bark	13600	44	5.9	21	73		9.9		
			Bolewood	134000	111	8.7	47	124		25.0		
			Root+stump	25000	35	6.0	20	29		8.0		
			Understory									
			Herbs	170	2.8	.6	5.7	1.9		.5		
			Shrub leaf	140	3.6	.4	1.7	3.1		.6		
			Shrub twig	900	4.5	.5	2.2	7.5		.6		
U.S.S.R.	Pinus sp.	71	Aboveground	216000	510	40	230	360	50			Rodin & Bazilevich 1967
N. Carolina, USA	Pinus strobus	15	Overstory:									Swank in Cole & Rapp 1980
			Foliage Total	4664	72.8		22.7	17.6				
			Branches	22825	78.8		45.4	47.5		4664		
			Bolles	42110	72.4		40.9	32.6				
			Roots	60300	422.1		163.2	203.6				
U.S.S.R.	Pinus sylvestris	100	Foliage	15100								P'yavchenko 1960a, 1960b (cited in Rodin and Basilevich 1967)
			Woody	17900								
			Roots	4000								
			Total	37000	229							
Central Sweden	Pinus sylvestris	120- 150	Current needles	1260	15	1.5	6.7	1.8	1.0	Na 0.06	Bringmark 1977	
			Older needles	2675	36	3.3	12.1	8.3	1.6	Na 0.16	S 0.67	
			Current shoots	260	2.6	0.36	1.3	0.38	0.21	Na 0.01	S 1.55	
			Older shoots	560	3.9	0.48	2.7	1.6	0.44	Na 0.03	S 0.12	
			Branches	8100	22	2.1	10.1	16	3.2	Na 0.24	S 0.25	
			Stemwood	45200	24	1.8	14.0	24.4	6.3	Na 0.45	S 2.4	
			Stembark	3050	10	1.0	2.9	10.6	1.3	Na 0.15	S 4.5	
			Stump & big roots	14240	11	1.3	9.3	5.6	1.7	Na 0.10	S 0.67	
			Roots 1-5 cm	2900	3.5	0.6	3.3	1.9	0.7	Na 0.06	S 1.28	
			Roots <1 cm	2950	5.3	1.1	4.9	3.1	1.7	Na 0.21	S 0.64	
			Dead branches	570	2.2	0.15	0.55	1.5	0.19	Na 0.03	S 1.18	
											S 0.22	

Table 4 Standing Crop Biomass & Nutrient Content

Location	Dom. Veg.	Age	Component	Biomass	kg/ha		P	K	Ca	Mg	Other	Reference
					N							
Sweden												
			Shrubs									
			aboveground	1970	14.4	1.2	5.4	6.8	1.7	Na 0.34		
										S 2.14		
			belowground	3470	17.9	2.1	4.5	4.5	1.3	Na 0.30		
										S 3.18		
			Moss & lichens	2510	19.7	1.7	7.8	3.9	1.1	Na 0.32		
										S 1.34		
			Wood	24200	18.4	1.9	8.2	12.1	4.6			Holmen 1964
			Bark	3000	10.2	1.3	4.7	18.6	2.0			
			Live branches	7100	31.8	4.0	13.4	21.2	4.5			
			Needles	3500	47.2	4.8	17.0	11.8	4.5			
			Dead branches	1600	4.9	.3	.7	5.4				
Finland												
			Stemwood	4455	622	1382	3361	730				Lehtonen 1978
			Bark	1247	423	1027	1282	307				
			Live branches	7615	1476	4369	8364	1315				
			Dead branches	857	70	164	984	110				
			1st Yr. Needles	541	183	462	231	84				
			2nd Yr. Needles	610	175	606	462	91				
			3rd Yr. Needles	720	130	316	392	77				
			Buds	29	1	18	11	5				
			Stump wood & roots	2931	578	1883	1373	618				
			Total	19005	3648	10227	16460	3337				
U.S.S.R.												
			Foliage	13900								Remezov et al.
			Woody	203400								(cited in Rodin and
			Roots	63600								Basilevich 1967)
			Total	279900	664						Ash 1214	
Sweden												
			Stem wood	17	1.4	12	19					Popovic & Burgtorf 1964
			Bark	9	7.5	6	13					
			Live Branch	18	2.1	10	16					
			Foliage	25	2.5	8	12					
			Dead Branch	2	.1	.4	3					
			Total	71	8	36	63					
Finland												
			Aboveground	97000	137	72	108					Malkonen, 1973
Finland												
			Stemwood	9630	5.78	.58	3.66	5.68				Malkonen 1975
			Bark	1940	6.54	.99	3.72	10.67				
			Dead Br.	780	2.68	.14	.34	2.43				
			Live Br.	3270	12.75	1.73	7.29	11.28				
			Needles	2320								
			1st Yr.		8.91	1.13	5.34	1.50				
			2nd Yr.		10.06	.95	3.74	3.83				
			3rd Yr.		5.33	.52	1.95	2.95				
			4th Yr.		1.25	.13	.49	.89				
			Aboveground parts	17940	53.3	6.17	26.53	39.23				
			Below ground parts	7040	21.1	4.16	12.03	9.96				
			Stumps	1440	1.41	.24	1.08	.96				
			Roots >1cm	2110	2.83	.36	1.67	1.46				
			Roots <1cm	3490	16.86	3.56	9.28	7.54				

Table 4 Standing Crop Biomass & Nutrient Content

Location	Dom. Veg.	Age	Component	Biomass	kg/ha					Other	Reference
					N	P	K	Ca	Mg		
			Herbs		O	O	O	O			
			Dwarf shrubs		14.04	1.20	5.58	7.38			
			Shrubs		.30	.04	.14	.10			
			Aboveground parts		27.24	2.65	12.39	11.63			
			Below ground parts		15.41	2.20	3.22	5.71			
U.K.	Pinus sylvestris	20	Foliage	12500							Ovington 1957
			Woody	39100							(cited in Rodin and
			Roots	14000							Basilievich, 1967)
			Total	65600	373					Ash 372	
England	Pinus sylvestris	55	Stand	150720	453	41	150	272	64		Ovington 1957, 1959
Sweden	Pinus sylvestris	39	Total	16300	46	5	19	17			Tamm 1969
		72	Total	47500	85	9	47	43			
U.S.S.R.	Pinus sylvestris	100	Total	81000	287						Rodin & Basilievich 1967
England	Pinus sylvestris	100	Total	37000	229						
		23	Leaves	5100	115	10	52	36	8	Na 1	Ovington, 1959a,b
			Branches	13800	60	5	28	34	10	1	(cited in Ovington, 1962)
			Trunks	44300	59	34	34	56	8	1	
			Roots	28100	189	11	35	48	16	6	
			Understory	200	2	<1	2	1	<1		
Scotland	Pinus sylvestris	33	Foliage	7300	89	9	43	36	6		Ovington & Madgwick 1959
			Branches	23700	79	9	43	43	9		
			Bolles	11800	97	12	84	115	24		
			Roots	36100	81	11	54	33	13		
U.S.S.R.	Pinus sylvestris	100	Foliage	6200							Manakov 1961, 1962a, 1962b
			Woody	56700							(cited in Rodin and
			Roots	17800							Basilievich 1967)
			Total	80700	287					Ash 458	
U.K.	Pinus sylvestris	39-	Aboveground + thinning	370000	417	38	237	359	72		Ovington 1962
U.K.	Pinus sylvestris	18	Needles	5900	56.8	6.0	35.4	15.0	5.5		Wright and Will 1958
			Branches	12500	37.5	4.7	34.3	22.5	6.5		Note: some totals
			Bark	6700	28.9	3.2	19.8	16.1	4.2		do not add up
			Wood	27100	21.4	1.9	20.9	12.9	5.7		precisely due to
			Total	52500	144.7	15.9	110.4	66.5	21.9		conversion of
		28	Needles	4500	64.3	6.9	24.7	13.9	4.1		pound/acre to
			Branches	13400	58.0	7.4	35.9	23.6	8.6		kg/ha.
			Bark	8000	36.5	4.8	22.0	19.3	6.2		
			Wood	64100	55.7	4.8	40.7	25.7	15.4		
			Total	90000	214.4	23.9	123.3	82.5	34.3		
		64	Needles	4500	48.8	5.3	18.2	21.4	3.6		
			Branches	16000	50.9	6.3	27.9	34.3	7.6		
			Bark	13600	35.4	5.5	18.2	79.3	6.0		
			Wood	79500	61.1	4.7	31.1	57.9	16.0		
			Total	113600	196.2	21.8	95.4	193.0	33.23		

Table 4 Standing Crop Biomass & Nutrient Content

Location	Dom. Veg.	Age	Component	Biomass	kg/ha		P	K	Ca	Mg	Other	Reference
					N							
U.S.S.R.	Pinus sylvestris	71	Total	28000	664							Rodin & Bazilevich 1967
N. Carolina, USA	Pinus taeda											Wells and Jorgensen 1975
		11	Aboveground	77000				56	138	29		Jorgensen 1975
			Roots	14000				24	36	11		Nemeth 1972
		12	Aboveground	91000				59	158	33		and Wheeler 1972
			Roots	16000				28	41	13		(cited in Wells and Jorgensen 1975)
U.S.A.	Pinus taeda	30	Aboveground	176400	212	31	132	132	127	41		Switzer et al 1966, 1968 (adapted by Foster and Morrison 1976)
Mississippi, USA	Pinus taeda	5	Aboveground	6000	38							Smith et al. 1971
		4	Aboveground	16000	72							(cited in Wells and Jorgensen 1975)
N. Carolina, USA	Pinus taeda	16	Leaves	8000	82	10	48					Jorgensen, Wells and Metz, 1975
			Branches	23200	60	6	28					
			Trunks	109600	79	11	65					
			Bark	15200	36	4	24					
			Roots	36300	64	17	61					
			Total	192300	321	48	226					
Japan	Pinus taeda	7	Aboveground	46000	235	21	51	100	44			Akai et al. 1968 & 1972 (cited in Wells and Jorgensen 1975)
		34	Aboveground	197000	422	142	238	445	75			
N. Carolina, USA	Pinus taeda	4	Leaves		20.5	2.9	12.5		9.6	2.3		Haines and Sanderford 1975
			Bark		0.9	0.1	0.9		0.7	0.1		
			Wood		6.2	0.5	4.5		2.9	1.1		
			Total		27.6	3.5	17.9		13.2	3.5		
			Leaves		25.0	3.0	16.1		8.5	2.1		
			Bark		2.7	0.3	1.8		1.5	0.4		
			Wood		7.1	1.0	5.4		3.2	1.1		
			Total		34.8	4.3	23.3		13.2	3.6		
S.E. USA	Pinus taeda	10	Aboveground	28000	80	7	40	25	8			Switzer, Nelson and Smith 1968 (estimated from graph)
		20	Aboveground	90000	165	12	95	70	22			
		30	Aboveground		210	20	125	125	40			
		40	Aboveground		235	25	145	165	50			
		50	Aboveground		250	25	150	180	65			
		60	Aboveground		250	25	155	185	65			

Table 4 Standing Crop Biomass & Nutrient Content

Location	Dom. Veg.	Age	Component	Biomass	kg/ha		P	K	Ca	Mg	Other	Reference
U.S.A.	Pinus virginiana	27-31	Aboveground				8	65	105	26		Madgwick 1970 (cited in Foster and Morrison 1976)
Ohio, USA	Platanus occidentalis	4	Aboveground									Wittwer & Immel 1980
			Foliage	2500	47	4		27	45			
			Branches	6300	28	4		14	42		Mn 0.33	
			Stem	22600	52	14		49	24		Mn 0.15	
			Bark	3600	22	6		8	65		Mn 0.62	
			Total tree	35000	149	28		98	176		Mn 0.17	
											Mn 1.27	
Minnesota, USA	Populus tremuloides	40	Foliage	3600	87	9		47	37	6		Alban et al., 1978
			Branches	16600	82	11		42	215	12		
			Wood	119000	84	10		112	171	19		
			Bark	27600	115	16		86	435	20		
			Roots	3800	89	20		80	216	18		
Wisconsin, USA	Populus tremuloides	45	Stand	166945	207	21		107	441	43		Boyle et al., 1973
U.S.S.R.	Populus	25	Foliage	3400								Remezov et al., 1959 (cited in Rodin and Basilovich 1967)
			Woody	14700								
			Roots	35900							Ash 1925	
			Total	186300	680							
Minnesota, USA	Populus tremuloides	49	Overstory									Perala & Alban, 1979
			Foliage	4200	89	10.9		35	64	10.3		
			Live branch	26400	103	19.8		65	262	20.4		
			Dead branch	3200	7	.6		3	35	1.8		
			Bark	30000	114	17.2		71	549	25.6		
			Bolewood	118000	92	8.4		81	182	26.0		
			Root+stump	29000	73	15		94	298	24.0		
			Understory									
			Herbs	430	6.4	1.6		14.8	4.3	1.2		
			Shrub leaves	340	7.8	1.4		5.2	7.3	1.4		
			Shrub stems	2900	13.1	1.9		7.8	22.0	1.5		
U.S.S.R.	Populus	50	Foliage	4800								Remezov et al., 1959 (cited in Rodin and Basilovich 1967)
			Woody	253000								
			Roots	47100							Ash 3938	
			Total	304800	1095							

Table 4 Standing Crop Biomass & Nutrient Content

Location	Dom. Veg.	Age	Component	Biomass	kg/ha			K	Ca	Mg	Other	Reference
					N	P						
Ohio, USA	Populus sp.	4	Aboveground									Wittwer & Immel 1980
			Foliage	1900	38	4		27	40	7	Mn 0.26	
			Branches	750	64	10		50	64	9	Mn 0.36	
			Stem	27600	44	14		53	42	12	Mn 0.28	
			Bark	7600	75	8		48	117	10	Mn 0.81	
			Total tree	44600	221	36		178	263	38	Mn 1.71	
New Hampshire, USA	Prunus, Betula	4	Leaves	18	15.7	1.0		5.5	3.5	0.7		Safford and Philip 1974
			Branches +stem		18.9	2.0		10.1	8.4	0.5		
		4 (fert.)	Leaves		34.7	3.3		11.4	9.1	2.4		
			Branches +stem		74.9	11.7		47.2	32.6	3.5		Binkley 1983
Washington, USA	Pseudotsuga	23	Douglas-fir									
			Foliage	15480	240							
			Branches	24600	31							
			Stems	218200	170							
	Pseudotsuga/	23	Douglas-fir									
	Ainus rubra		Foliage	11000	171							
			Branches	15430	20							
			Stems	140890	109							
			Alder									
			Foliage	2300	54							
			Branches	10090	65							
			Stems	38300	79							
B.C., Canada	Pseudotsuga	23	Douglas-fir									Binkley 1982, 1983
			Foliage	9600	89	20		57	47	9	S 35.4	Binkley et al. 1984
			Branches	13300	13	2		7	6	<1		
			Stems	35000	27	3		12	14	2	S 5.3	
			Understory									
			Conifers	9500	16	3		7	11	2		
			Shrubs & herbs	2500	27	3		23	18	5		
	Pseudotsuga, Ainus sinuata	23	Douglas-fir									
			Foliage	9900	110	11		54	42	7	S 20.9	
			Branches	13900	17	3		11	6	<1		
			Stems	45900	28	5		31	18	2	S 11.5	
			Alder									
			Foliage	1800	56	5		16	10	5	S 5.2	
			Stems	23800	50	3		13	12	4	S 5.5	
			Understory									
			Conifers	1700	3	1		1	2	1		
			Shrubs & herbs	1100	12	2		10	8	2		
	Pseudotsuga, Ainus rubra	23	Douglas-fir									
			Foliage	3390	55	3.1		17.3	17.6	3.1	S 8.1	
			Branches	5500	7	1.1		4.4	2.4	<1		
			Stems	41240	32	3.3		14	17	2	S 5.8	
			Alder									
			Foliage	2900	89	6.6		7	15	7	S 8.1	
			Branches	7490	48	1.8		20	15	7		
			Stems	53520	110	4.6		52	43	11	S 12.8	

Table 4 Standing Crop Biomass & Nutrient Content

Location	Dom. Veg.	Age	Component	Biomass	kg/ha	N	P	K	Ca	Mg	Other	Reference
Whidbey			Fert. Dead branches		14.2	2.4	1.6					
			Unfert. Bark		53.3	10.1	49.5					
			Fert. Bark		66.7	12.0	38.9					
			Unfert. Wood		55.3	6.9	4.0					
			Fert. Wood		45.0	5.4	3.2					
			Unfert. Total		260.0	50.0	138.0					
			Fert. Total		430.6	57.9	130.0					
			Unfert. Needles		125.5	43.2	74.1					
			Fert. Needles		170.8	32.3	105.9					
			Unfert. Live branches		54.6	9.5	37.3					
			Fert. Live branches		83.2	10.9	49.7					
			Unfert. Dead branches		24.6	2.1	3.8					
			Fert. Dead branches		24.2	3.7	7.7					
			Unfert. Bark		82.0	11.0	52.6					
			Fert. Bark		103.8	13.5	64.1					
Washington, USA	Pseudotsuga menziesii (plantation)	9	Unfert. Wood		73.7	5.8	5.1					
			Fert. Wood		72.6	5.7	5.0					
			Unfert. Total		360.5	71.7	173.0					
			Fert. Total		454.7	66.1	232.5					
		22	Fert. Foliage		12.8	2.5	7.9		6.3	1.2		Turner 1975
			Branches		7.1	2.0	9.3		11.3	2.0		
			Stems		13.5	1.0	42.3		25.6	7.6		
			Understory		46.1	11.3	51.9		48.0	15.3		
		30	Roots		2.3	.9	1.5		2.1	.3		
			Foliage		65.1	12.5	42.6		27.0	5.8		
			Branches		17.6	7.1	40.3		34.7	7.9		
			Stems		144.6	92.6	48.0		140.6	15.3		
		30	Understory		66.6	8.7	59.4		68.7	18.5		
			Foliage		54.2	13.5	42.4		39.8	6.7		
			Branches		23.8	5.4	19.6		54.2	5.1		
			Stems		142.8	19.8	126.0		153.8	26.0		
	Pseudotsuga menziesii (plantation)	30	Understory		47.8	5.8	26.7		52.0	11.1		
			Foliage		98.0	21.1	66.7		73.1	14.6		
			Branches		49.0	9.3	28.7		70.5	7.4		
			Stems		169.0	24.1	107.0		214.6	31.1		
	Pseudotsuga menziesii	42	Understory		29.0	4.6	24.1		25.1	5.7		
			Roots		2.3	0.9	1.5		2.1	0.3		
			Foliage		105.5	22.3	73.4		68.1	9.9		
			Branches		24.2	10.5	39.2		45.8	11.8		
		48	Stems		225.8	25.2	109.8		159.3	22.9		
			Understory		38.6	4.1	14.7		41.5	9.8		
			Foliage		108.0	25.0	66.0		59.0	15.0		
			Branches		55.0	9.0	32.0		45.0	9.0		
		73	Stems		168.0	25.0	100.0		192.0	28.0		
			Understory		28.0	4.0	23.0		23.0	5.0		
			Foliage		113.7	24.2	75.7		114.9	14.0		
			Branches		62.2	5.8	60.7		71.9	7.4		
		95	Stems		174.4	24.5	216.9		246.5	36.8		
			Understory		17.8	4.7	15.1		14.7	4.1		
			Foliage		108.6	28.4	66.3		100.7	14.9		
			Branches		59.0	12.1	32.2		92.8	8.4		
			Stems		277.7	39.4	155.1		239.8	34.3		
			Understory		8.6	1.9	6.8		4.5	1.7		

Table 4 Standing Crop Biomass & Nutrient Content

Location	Dom. Veg.	Age	Component	Biomass	kg/ha			K	Ca	Mg	Other	Reference
					N	P						
U.S.A.	Pseudotsuga	38	Aboveground-trees	152900	260	50	138					Heilman 1961 (cited in Ovington 1962)
			Roots	16900	67	12	43					
			Understory		10		8					
Oregon, USA	Pseudotsuga menziesii	95	Foliage		154.0	40.0	95.0		88.0	16.0		Grier unpublished cited in Cole et al., 1967
			Branches		87.0	20.0	60.0		195.0	17.0		
			Stems		276.0	30.0	55.0		385.0	60.0		
			Understory		14.0	6.0	14.0		38.0	4.0		
			Foliage		135.0	32.0	67.0		98.0	13.0		
	Pseudotsuga menziesii	130	Branches		65.0	16.0	50.0		153.0	15.0		
			Stems		186.0	20.0	36.0		260.0	40.0		
			Understory		5.0	1.0	4.0		5.0	1.0		
Washington, USA	Pseudotsuga	36	Leaves									Cole, Gessel and Dice 1967
			current	1990	24	5	16		7			
			older	7107	78	24	46		66			
			Branches									
			current	513	4	1	3		2			
			older	13373	40	9	32		65			
			dead	8145	17	2	3		39			
			Wood									
			current	7485	10	2	10		4			
			older	114202	67	7	42		43			
			Bark	18728	48	10	44		70			
			Roots	32896	32	6	24		37			
			Understory	1010	5	1	7		9			
U.S.A.	Pseudotsuga	32	Aboveground-trees	34200	84	26	54					Heilman 1961 (cited in Ovington 1962)
			Roots	20700	68	13	55					
			Understory	3200	21	3	22					
England	Pseudotsuga	21	Leaves +Branches	24500	213	13	68		98	18	Na 8	Ovington 1962
			Trunks	90300	99		63		54	11	2	
			Understory	200	4	<1	5		1	1		
England	Pseudotsuga	47	Leaves +Branches	49700	311	34	136		246	38	Na 6	Ovington 1962
			Trunks	202700	157	15	73		92	24	4	
			Understory	3600	49	6	39		23	5	2	

Table 4 Standing Crop Biomass & Nutrient Content

Location	Dom. Veg.	Age	Component	Biomass	kg/ha					Other	Reference
					N	P	K	Ca	Mg		
Washington, USA	Pseudotsuga, high productivity	53	Foliage	12300	148	27	64				Bigger & Cole 1983
			Branches	24800	102	12	37				
			Boles	281000	478	56	225				
			Understory	592	6.5	0.8	5.5				
			Forest floor	17600	214	21	26				
			Soil to 50 cm	121400	2066						
			Total	458000	3011						
Korea	Quercus acutissima	12	Leaves	5275	41	6.5	40				Mun et al. 1977
			Branches	12000	40	3.0	14				
			Stems	52150	127	8.5	34				
			Roots	17360	72	7.5	72				
			Understory	3200	66	3.5	57				
			Total	219370	1157	101	1258	4549	311	Mn 124	
Oklehoma, USA	Quercus	80	Total								Johnson & Risser 1974
U.S.S.R.	Quercus	12	Foliage	3300							Remezov et al. 1959 (cited in Rodin and Basilevich 1967)
			Woody	43000						Ash 1127	
			Roots	22700							
			Total	69000	278						
U.S.S.R.	Quercus	40	Foliage	4100							After Dzents-Litovskaya 1960 (cited in Rodin and Basilevich 1967)
			Woody	118900						Ash 2187	
			Roots	31800							
			Total	154800							
U.S.S.R.	Quercus	43	Foliage	3800							Mira, 1955 (cited in Rodin and Basilevich 1967)
			Woody	104900						Ash 2012	
			Roots	45900							
			Total	154600	628						
U.K.	Quercus	47	Stand, litter & understory	134000	464	40	254	292			Ovington 1962
U.S.S.R.	Quercus	48	Foliage	3600							Remezov et al. 1959 (cited in Rodin and Basilevich 1967)
			Woody	187000							
			Roots	70200						Ash 2570	
			Total	260800	952						
Belgium	Quercus	80	Overstory:								Duvigneud, Denaeayer 1970
			Foliage Total	3458	73.0	4.7	36.0	54.0	4.6		
			Branches	36425	295.0	23.0	164.0	776.0	72.0		
			Boles	75202							
			Roots	34600	121.0	10.0	92.0	372.0	19.0		
			Understory veg.	4700	46.0	4.6	46.0	70.0	6.0		

Table 4 Standing Crop Biomass & Nutrient Content

Location	Dom. Veg.	Age	Component	Biomass	kg/ha				Ca	Mg	Other	Reference
					N	P	K					
U.S.S.R.	Quercus	220	Foliage	3700								Mira, 1955 (Cited in Rodin and Bazilevich 1967)
			Woody	402800								
			Roots	97300							Ash	
			Total	503800	1258						6396	
Missouri, USA	Quercus	35-92	Trees	94780	121.6	10.4	67.1	463.4	23.4			Rochow 1975
			Shrublayer	5120	16.5	1.8	9.8	37.3	2.7			
			Herb	175	2.1	0.3	2.8	2.6	0.4			
			Total									
Roquet, France	Quercus ilex	150	Overstory:									Loissant, Rapp in Cole & Rapp 1980
			Foliage Total	7000	93.0	10.0	43.0	70.0	9.0			
			Branches	27000	135.0	40.0	90.0	493.0	25.0			
			Bolies	235000	517.0	174.0	493.0	3290.0	117.0			
			Roots	45000	153.0	81.0	85.0	1147.0	7.2			
			Understory veg.									
				340	2.3	.1	17.0	4.1	1.1			
England	Quercus petraea	21	Leaves	14100	214	13	61	61	17	Na	3	Ovington 1962
			+Branches									
			Trunks	28300	70	6	41	58	11		1	
			Understory	600	11	1	14	4	2		1	
Tennessee, USA	Quercus prinus	30-80	Overstory:									Harris in Cole & Rapp 1980
			Foliage Total	5300	75.0	5.0	52.0	58.0	12.0			
			Branches	30000	139.0	10.0	61.0	294.0	13.0			
			Bolies	102000	183.0	11.0	129.0	500.0	20.0			
			Roots	36000	132.0	22.0	140.0	249.0	18.0			
England	Quercus robur	47	Leaves	21700	218	21	105	73	18	Na	1	Ovington 1962
			+Branches									
			Trunks	106600	151	11	118	173	23		3	
			Understory	1600	24	3	23	11	4		1	
U.S.S.R.	Quercus robur	220	Total	504000	1258							Rodin & Bazilevich 1967
U.K.	Quercus robur	39-47	Aboveground	185000	449	38	286	338	53			Ovington 1962
			+ thinning									
Belgium	Quercus robur, mixed	115-160	Overstory:									Duvigneud, Denaeayer 1970
			Foliage Total	3500	83.0	6.0	40.0	34.0	7.0			
			Branches	78300	259.0	23.0	139.0	339.0	27.0			
			Bolies	210050	386.0	17.0	219.0	769.0	58.0			
			Roots	35300	297.0	29.3	112.0	301.7	27.7			
			Understory veg.	30580	166.0	14.0	112.0	172.0	32.0			

Table 4 Standing Crop Biomass & Nutrient Content

Location	Dom. Veg.	Age	Component	Biomass	kg/ha		P	K	Ca	Mg	Other	Reference
					N							
Meadow Wood, G.B.	Quercus, Betula, Mixed decid.	80	Overstory:									Satchell in Cole & Rapp 1980
			Foliage Total	3505	85.7	4.6	38.9	41.9	9.5			
			Branches	33640	58.8	3.7	61.1	137.4	8.0			
			Boles	75920	133.6	8.4	113.1	301.0	8.5			
			Roots	24218	223.0	11.9	112.8	235.3	30.8			
			Understory veg.	15529	8.1	5.4	42.9	66.9	9.7			
N. Carolina, USA	Quercus, Carya Acer		Stand	190000	995		400	830				Henderson et al., 1978
Tennessee, USA	Quercus, Carya	30- 80	Overstory:									Harris in Cole & Rapp 1980
			Foliage Total	5600	67.0	6.0	53.0	70.0	17.0			
			Branches	26000	131.0	9.0	53.0	288.0	19.0			
			Boles	90000	171.0	9.0	114.0	498.0	31.0			
			Roots	33000	128.0	22.0	136.0	244.0	19.0			
Tennessee, USA	Quercus, Carya		Stand	156000	470		340	980				Henderson et al., 1978
N. Carolina, USA	Quercus, Carya	60- 200	Overstory:									Swank in Cole & Rapp 1980
			Foliage Total	5584	95.0		46.0	49.0				
			Branches	25599	116.0		46.0	133.0				
			Boles	106313	194.0		135.0	361.0				
			Roots	52525	434.0		167.0	278.0				
Illinois.	Quercus, Carya	150	Total:xeric mesic	237300								Rolfe et al., 1978
			Foliage:xeric mesic	243700								
			Twigs:xeric mesic	5200								
			Twigs:mesic	6200								
			Limbs:xeric	6800								
			Limbs:mesic	45700								
			Boles:xeric	46800								
			Boles:mesic	127300								
			Above-ground xeric mesic	130600								
			Aerial parts	190500								
			Foliage	194900								
			Twigs		478	29	310	1603	105			
			Limbs		63	4.9	59.6	64.4	17.9			
			Boles		35	1.5	21.3	107.3	9.6			
			Roots		126	7.8	110.7	601.2	33.1			
					252	14.7	115	837.3	44.2			
					153	12	109	426	26			

Table 4 Standing Crop Biomass & Nutrient Content

Location	Dom. Veg.	Age	Component	Biomass	kg/ha		P	K	Ca	Mg	Other	Reference
					N							
Belgium	Quercus, Fagus	75	Stand	156000	533	44	342	1248	102			Duvigneaud & Denaeyer-de Smet, 1970
Belgium	Quercus, Fagus, Carpinus	70-75	Total	147000	474	36	286	1165	93	Mn 70		Duvigneaud & Denaeyer-de Smet 1970
Belgium	Quercus, Fraxinus	100+	Aboveground	380000	947	63	493	1338	126			Duvigneaud & Denaeyer-de Smet, 1970
U.S.S.R.	Tilia	40	Foliage Woody Roots Total	2800 116800 38900 158500							Ash 1937	Remezov et al., 1959 (cited in Rodin and Basilevich 1967)
U.S.S.R.	Tilia	74	Foliage Woody Roots Total	4500 165100 55400 22500							Ash 2686	Remezov et al., 1959 (cited in Rodin and Basilevich 1967)
Oregon, USA	Tsuga heterophylla Picea sitchensis	30	Foliage Branches Stems understory Roots	231.9 63.5 170.1	29.2 10.2 43.6	83.1 32.0 42.1	49.5 32.0 135.3	21.7 6.8 15.3				Grier unpublished cited in Cole et al.
	Tsuga heterophylla Picea sitchensis	121	Foliage Branches Stems Understory Roots	98.8 85.2 76.1 584.6 15.7 178.7	22.2 10.9 10.8 148.9 3.4 43.5	36.2 31.1 30.8 138.3 9.7 61.0	59.6 19.3 52.5 432.8 7.7 152.6	14.4 7.5 8.8 46.9 2.2 33.5				
B.C., Canada	Tsuga heterophylla Chamaecyparis nootkatensis	250	Leaves +twigs Branches small large Bark Trunks Total	3800 5700 5300 7200 34300 56300	27 8 6 12 16 70	4 1 1 2 5 13	12 5 4 37 24 53	24 12 12 37 22 107	3 1 1 1 4 11			Krumlik and Kimmins 1976 (Figures may not be additive due to rounding errors)
Oregon, USA	Tsuga mertensiana & Abies concolor	130	Foliage Branches Stems Understory Roots	140.0 68.0 186.0 15.0 108.0	39.0 14.0 14.0 1.0 9.0	100.0 47.0 39.0 9.0 36.0	130.0 130.0 236.0 11.0 167.0	20.0 13.0 36.0 1.0 30.0				Grier unpublished in Cole et al.

Table 5 Forest Floor Biomass and Nutrient Content

Location	Dom. Veg.	Age	Component/ Horizon	Biomass	N	P	K	Ca	Mg	Other	Reference
kg/ha											
New Hampshire, <i>Abies balsamea</i>											
			Forest floor								Lang et al., 1981
			O1 horizon	75000	1800	150	60	150	52	Na 5	
			O2 horizon	17200	500	67	36	17	47	Na 3	
			Total	92200	2300	217	96	167	99	Na 8	
			Branches								
			Slight-								
			mod. decay	3300	10	<1	<1	2	<1	Na <1	
			Adv. decay	1400	4	<1	<1	2	<1	Na <1	
			Total	4700	14	1	1	7	1	Na <1	
			Bole wood								
			Slight decay	300	1	<1	<1	1	<1	Na <1	
			Mod. decay	4800	10	4	<1	8	<1	Na <1	
			Adv. decay	3700	11	3	<1	7	<1	Na <1	
			Total	8800	22	7	1	16	2	Na <1	
			Buried wood	3900	22	2	1	7	<1	Na <1	
Oregon, USA	<i>Abies concolor</i>	23 180	Forest floor		666.0	55.0	219.0	170.6	219.0		Grier (unpubl.)
			Forest floor		2090.0	137.0	700.0	4805.0	343.0		cited in Cole et al.
New Mexico	<i>Abies concolor</i>		Total	80800	883	85	235	2674	339	S 173 Mn 46.0 Zn 7.9	Wollum, 1973
Japan	<i>Abies firma</i> <i>Tsuga sieboldii</i>	97- 145 120- 443	L	4279	484.0	32.0	113.0	182.0	67.0		Ando in Cole & Rapp, 1980
				50780	506.8	34.1	76.3	159.0	30.0		
Colorado, USA	<i>Abies lasiocarpa</i>		Non-woody	55506	498	55	182	724	170		Snell et al., 1979
			Woody	47433	100	12	40	103	11		
Japan	<i>Abies may.</i>		Total	10500	1218	236	242	642	390		Tsutsumi, 1971
Oregon, USA	<i>Abies nobilis</i>	130	Forest floor		884.0	213.0	75.0	515.0	205.0		Grier (unpubl.) cited in Cole et al.
New England, USA	<i>Abies, Betula</i>	75	Total	117000	1815						Vitousek et al., 1982

Table 5 Forest Floor Biomass and Nutrient Content

Location	Dom. Veg.	Age	Component/ Horizon	Biomass	kg/ha					Mg	Other	Reference
					N	P	K	Ca	Mg			
		38		248	16	22	118	36			Fe 419 Mn 19 Cu 1.7 Zn 1.4 S 25 Fe 326 Mn 18 Cu 0.7 Zn 1.1 S 23 Fe 306 Mn 18 Cu 0.6 Zn 1.0 S 43 Fe 517 Mn 30 Cu 1.1 Zn 1.5	Turner, 1975
		42		258	21	24	128	24				Turner et al., 1976
		45		405	24	26	120	42				Bormann & DeBell, 1981
Washington, USA	<i>Alnus rubra</i>	30	L	66350	877.0	45.0	91.0	391.0	57.0			Binkley, 1982
Washington, USA	<i>Alnus rubra</i>	34	Total	1156								Mun et al., 1977
Washington, USA	<i>Alnus rubra</i>	5-41	Total	13000- 29000	250- 730							Binkley, 1983
Washington, USA	<i>Alnus rubra</i> , <i>pseudotsuga</i>	23	Total	23040	280							Binkley et al., 1982
Korea	<i>Alnus sibirica</i>	12	L	5120	22	13	9					Kittredge, 1940
B.C., Canada	<i>Alnus sinuata</i>	5	Total	2450	47	6	2	25	10			van Cleve and Noonan, 1971
B.C., Canada	<i>Alnus/pseudo.</i>	18	L + F	19900	340	29	19	144	40			
California, USA	<i>Arbutus</i>	30		23969								
Alaska, USA	<i>Betula</i> (7 stands)	25-120	L	3097	24.8	3.7	5.6	43.7	7.7			
			F	7710	121.0	9.2	12.3	106.4	19.3			
			H	29707	487.2	38.6	53.5	279.2	62.4			
			Total	40515	633.0	51.6	71.4	429.3	89.4			

Table 5. Forest floor biomass and nutrient content

Location	Dom. Veg.	Age	Component/ Horizon	Biomass	N	P	K	Ca	Mg	Other	Reference
N. Carolina, USA	<i>Betula lutea</i> <i>Betula lutea</i>	100+ 60		60600 39700		49.2 74.8	139.4 143.6	407.8 381.0	161.8 130.4		Weaver & De Selm 1973
Japan	<i>Betula papyrif.</i>			14000	168	8.6	30	165	28		Tsutsumi, 1971
Alaska, USA	<i>Betula papyrif.</i>	50	L	68772.0	548.0	79.0	99.0	489.0	139.0		Van Cleave in Cole & Rapp, 1980
Washington, USA	Conifer -duff mull	old	L F H	13657 17971 71722	171 266 957	15 22 77	15 21 67				Gessel & Balci, 1965
Washington USA	Conifer mix (on Basalt)		L F H L F H	1920 2080 4580 1710 2290 2500	200 252 336 154 267 249	26 33 60 17 26 19	28 50 235 37 176				Woodrudge, 1968
Japan	<i>Cryptomeria</i>		Total	8000- 30000	56- 282	2.4- 12.4	5.6- 44.3	48.2- 58.8	17.6- 20.2		Kawana et al., 1979
Japan	<i>Cryptomeria</i>			12000	80	8.4	14	157	44		Tsutsumi, 1971
Japan	<i>Cryptomeria</i>			24000	184	8.2	18	304	86		Tsutsumi, 1971
California, USA	<i>Cupressus</i>	30		30640							Kittredge, 1940
Maroonah, Victoria Australia	<i>E. regnans</i> <i>E. obliqua</i> <i>E. dives</i>	38 38	Total Total	47500 13100	394 132	11 3	32 9	126 40	39 14	Na 4	Feller, 1981
Stradbroke Is. Qld., Australia	<i>Eucalyptus</i>	?	Total	27000	195	6.8	23	142	34	Na	Westman and Rogers 1977a
SW Western Australia	<i>Eucalyptus diversicolor</i> <i>E. diversicolor</i> <i>E. calophylla</i>	35 all	Total Total Total	27300 19500	224 105	7 5	32 26	396 234	60 48	S Na Na	Mingston et al., 1979

Table 5 Forest Floor Biomass and Nutrient Content

Location	Dom. Veg.	Age	Component/ Horizon	kg/ha							Other	Reference
				Biomass	N	P	K	Ca	Mg			
Kyoto, Japan Shiga, Japan Kyoto, Japan	Fagus cren. Chamaecyparis Pinus dens.		Total	11600	105.4	6.8	8.8	111.6	10.0			Kawahara, 1971
			Total	17100	99.5	4.1	7.2	92.9	9.7			
			Total	19200	126.7	21.5	40.3	316.8	23.0			
Soliling, W. Germany	Fagus sylvatica		Total	29700	810	52	83	91	34	Na 14 Al 340 Na 20 Al 197		Ulrich et al. 1974 and Ulrich et al 1979
	Picea abies		Total	49000	960	53	41	83	20			
Sweden	Fagus sylvatica	45- 130	L	5200	86.0	5.8	104.0	34.2	4.8			Nihlgard, 1972
Germany	Fagus sylvatica	122	L	29700	810.0	52.0	83.0	91.0	34.0			Ulrich in Cole & Rapp, 1980
Japan	Larix leptolepis			13000	200	10.5	13	102	21			Tsutsumi, 1971
Tennessee, USA	Liriodendron	50	L	6000	77.9	5.3	9.2	99.6				Harris in Cole & Rapp, 1980
	Liriodendron, Carya, Quercus	30- 80	L	1500	187.0	11.0	14.0	294.0	22.0			
Japan	Mix. broad Mix. broad			5000 4000	62 52	3.3 2.9	8 12	27 116	9 17			Tsutsumi, 1971
Japan	Mixed		Total	6200	76	3.8	6.6	79.9	7.6			Katagiri et al. 1978
Japan	Mixed broad -lower slope		Total	4800	111	6.4	9.6	134.6	12.9			Katagiri & Isutsumi, 1978
	Mixed broad -upper slope		Total	15460	260	12	36.8	151.2	25.7			
Kyoto, Japan	Mixed broad Chamaecyparis		Total	15000	287.1	10.3	19.4	78.8	26.1			Iwatsuba, 1976
			Total	12300	112.9	5.1	11.8	37.0	5.8			
Meathop Wood, 1980	Mixed decid.	80	L	6120	74.4	3.3	12.0	101.0	8.1			Satchell in Cole & Rapp,
Tennessee, USA	Mixed hardwoods		Total	13310	150	12	25	200				West et al. 1981 (preliminary data)

Table 5 Forest Floor Biomass and Nutrient Content

Location	Dom. Veg.	Age	Component/ Horizon	Biomass	kg/ha							Other	Reference	
					N	P	K	Ca	Mg	Na	8			
New Zealand	Nothofagus	110	Total		125	7	15	215	23	Na	8		Miller (in Ovington, 1962)	
California, USA	Photinia	30		11861									Kittredge, 1940	
Minnesota, USA	Picea	40	Total		752		76	1398					Alban et al., 1978	
Minnesota, USA	Picea	41	Total	26000	509	40	43	753	46				Perala & Alban, 1979	
Sweden	Picea	100	F	25800	435								Nykqvist, 1977	
	Picea	139	L + F + H		1181	66.8	95	289	77					
Sweden	Picea		L + F + H		574	50.9	80	260	29					
	Picea	59	Total		770	28							Tamm, 1969	
	Picea Pinus	53 76	Total Total		290 740	15 27								
Germany	Picea abies	34	L	52000	1430.0	199.0	105.0	72.0	44.0				Ulrich in Cole & Rapp, 1980	
	Picea	87	L	49000	960.0	53.0	41.0	83.0	20.0					
	Picea	115	L	111000	2260.0	98.0	115.0	258.0	46.0					
USSR	Picea abies	45	L	19200									Kazimirov & Morozova, 1973	
Sweden	Picea abies	60	L	18500	245.0	15.4	15.0	47.9	7.5				Nihlgard, 1972	
England, UK	Picea abies	20	Total		294	20	31	73	23			3	Ovington, 1962 (summary)	
	Picea abies	47			360	19	30	65	27			4		
	Picea abies	47			436	24	21	117	19			5		
Alaska, USA	Picea mariana	51	L	88564	486.0	105.6	59.7	395.6	95.7				Van Cleave in Cole & Rapp, 1980	
	Picea	55	L	133260	656.5	152.1	145.4	231.3	224.5					
	Picea	130	L	119235	709.7	87.4	122.2	452.2	99.3					
Quebec, Canada	Picea mariana	65	Total		1214								Weetman and Webber 1972	
	Picea rubra		Total		1465									
New Mexico, USA	Picea, Abies	300	Total	65100	980								Vitousek et al., 1982	
Nova Scotia Canada	Picea, Abies	All	Total		900	62	110	290	32				Freedman et al., 1981	

Table 5 Forest Floor Biomass and Nutrient Content

Location	Dom. Veg.	Age	Component/ Horizon	Biomass	N	P	K	Ca	Mg	Other	Reference	
kg/ha												
Colorado, USA	Picea, Abies		L	2810			1.6	22.0	9.3	Na	0.3	Stottliemyer & Ralston, 1968
		F	3680			2.0	28.8	14.9		0.5		
		H	11210			11.0	87.8	61.0		1.3		
		Total	17700			14.6	138.6	85.2		2.1		
N. Carolina, USA	Picea, Abies	40-	Total	91000		93.6	287.9	328.0	210.7		Weaver, 1975	
Sweden	Picea, Pinus	65-132	L Spr. needles	2298	27.2	2.07	2.07	20.5		.92Na	.23	Nykqvist
			Pine needles	152	1.3	.11	.15	.8		.05Na	3.53	
			Branches	596	5.7	.48	.48	2.0		.18Na	.14	
			Branches <2	921	6.9	.55	.46	2.3		.18Na	.54	
			Branches 2-5	58	.4	.04	.03	.2		.01Na	.003	
			Branches >5mm	120	.8	.07	.16	.2		.05Na	.02	
			Bark								.008	
			Cones	822	5.7	.49	1.07	1.6		.33Na	.04	
			Deschampsia	246	2.9	.30	2.95	.5		.12Na	.057	
											.25	
			Vacc. myrt.	23	.3	.03	.08	.2		.03Na	.017	
											.26	
			Herbs	54	.9	.08	.12	.5		.07Na	.04	
			Pleurozium	602	7.8	.96	3.01	2.5		.42Na	.008	
			Dicranum	270	3.4	.41	2.16	1.1		.24Na	.18	
			Phlomis	59	.7	.09	.47	.2		.05Na	.084	
			Hylocum	107	1.3	.16	.86	.4		.10Na	.60	
			Unid'd	1840	22.7	1.66	1.84	7.0		.11Na	.34	
											.009	
			F Needles	810	11.2	.73	.58	4.1		.32Na	.08	
											.017	
			Branches	1894	18.4	1.25	1.25	5.5		.76Na	1.50	
			Branches <20								.141	
			Branches >20mm	269	2.5	.16	.16	.8		.11Na	.057	
			Bark	390	4.1	.23	.20	1.4		.17Na	1.04	
			Cones	2631	27.9	1.49	1.05	9.3		1.05Na	.141	
								1.24				
Resin	13							.022				
Dead roots	2851	27.2	1.85	3.14	6.1		1.35Na	.14				
								.019				
herbs	11	.1	.01	.004	.04		.004	.27				
								.176				
								1.23				
								.242				
								1.87				
								.004				

Table 5 Forest Floor Biomass and Nutrient Content

Location	Dom. Veg.	Age	Component/ Horizon	Biomass	kg/ha							Other	Reference
					N	P	K	Ca	Mg				
N.B., Canada	Pinus	16	moss	1075	16.1	1.38	1.31	4.1				Na .001 Mn .01	MacLean, 1978
			Unid'd	38688	550.1	34.11	29.52	121.7	20.92	Na .093 Mn 1.38			
			H	45740	372.6	8.86	25.07	74.1	41.98	Na 4.327 Mn 24.28			
			Total	99280	715	49.6	59.6	188.6	29.8				
			Total	104490	951	73.1	104.5	501.5	52.2				
Washington USA	Pinus (on Basalt)	49	Total	129250	1176	103.4	180.9	439.4	90.5				MacLean, 1978
			Total	74140	823	51.9	81.6	96.4	37.1				
			L	2490	168	22	37						
			F	3190	322	34	95						
			H	7330	115	33	97						
Minnesota, USA	Pinus banksiana	57	L	2000	149	21	36						Wooldrige, 1968
			F	2240	208	21	104						
			H	1660	141	20	100						
			Total-shallow		335	24	22	160	23				
			--deep		544	40	37	254	33				
Ontario, Canada	Pinus banksiana	20	Total	15971	234	17	19	91	18				Green & Grigal 1979 (in White & Harvey 1979)
			30	19967	328	26	43	88	88				
			65	25624	430	34	48	98	98				
			Total	25000	468	32	37	375	50				
			Total	25600	283	13	680	396	157				
Minnesota, USA	Pinus banksiana	41	Total		589		68	770					Perala & Alban, 1979 Morrison & Foster, 1979 Alban et al., 1978
			Total										
			Total										
			Total										
			Total										
Colorado, USA	Pinus contorta	40	L	4910			2.7	25.1	16.4	Na .6			Stottlemeyer & Ralston, 1968
			F	6870			3.8	35.0	27.8	.9			
			H	16810			16.5	85.8	91.5	2.0			
			Total	28590			23.0	145.9	135.7	3.5			
			Total										

Table 5 Forest Floor Biomass and Nutrient Content

Location	Dom. Veg.	Age	Component/ Horizon	Biomass	N	P	K	Ca	Mg	Other	Reference
kg/ha											
Japan	Pinus dens.		Total		121.8	4.44	23	80.1	12.3	Na 2.6	Nishimura, 1973
Japan	Pinus dens.			8000	96	5.5	11	61	12		Tsutsumi, 1971
Indiana, USA	Pinus echinata	33	Total	17250	134						Vitousek et al., 1982
Tennessee, USA	Pinus echinata	30	L	27000	290.0	18.0	21.0	256.0	23.0		Harris in Cole & Rapp, 1980
New Mexico	Pinus edulis		Total	9400	80	12	21	216	41	S 18 Mn 4.1 Zn 1.0	Wollum, 1973
	Pinus ponderosa		Total	25100	191	15	80	432	83	S 37 Mn 3.7 Zn 1.4	
	Pinus, Pseudo.		Total	25500	234	14	178	929	62	S 29 Mn 3.8 Zn 2.0	
Scotland	Pinus nigra	40	L	10800							Miller & Miller 1976
			H	13100							Miller, Miller and Pauline 1976
			Total	23900	304	57	39	87	26	Na 13	Ovington, 1954
England, UK	Pinus nigra	21	L	3907							
			F+H	14251							
			Total	18158							
	Larix leptolepis	21	L	1825							
			F+H	12282							
			Total	14107							
New Mexico, USA	Pinus ponderosa	200	Total	113000	1240						Vitousek et al., 1982
Arizona, USA	Pinus ponderosa	30-150	<2mm								
			Before burn	19800	410	48	53	286	127		Covington, 1978
			After burn	15850	380	56	76	645	235		
			After burn + 7 months	11840	257	47	75	583	158		
Arizona, USA	Pinus ponderosa	49	Needles	1304	8						Klemmedson, 1975
			Branches	12488	48						
			Wood	1500	3						
			Humus	18570	170						
			F+H	12890	62						
			Other OM	74	-						

Table 5 Forest Floor Biomass and Nutrient Content

kg/ha

Location	Dom. Veg.	Age	Component/ Horizon	Biomass	N	P	K	Ca	Mg	Other	Reference
Arizona, USA	Pinus ponderosa	60	Basalt. med. site L. 11400 med. site F. 13800 Limestone L. 12100 good site F. 19500 Sandstone L. 8000 poor site F. 12300								Binkley (unpub. data)
New Mexico	Pinus ponderosa		Total	27700	250	15	141	139	38	S 31 Mn 7.6 Zn 2.1	Wollum, 1973
	Pinus ponderosa		Total	32300	314	24	281	219	29	S 38 Mn 14.9 Zn 2.2	
Arizona, USA	Pinus ponderosa	43	unthinned	33000	306	27	80	160	135	Mn 146 S 36 Zn 36	Wollum & Schubert, 1975
			med. thinned	25000	225	19	57	125	90	Mn 94 S 24 Zn 26	
			heavy thinned	20000	180	15	43	100	62	Mn 52 S 17 Zn 20	
NWS, Australia	Pinus radiata	?	L	5813	68	6	14	26	5	B 0.06 Zn 0.37 Cu 0.40 Mn 4.6	Ballard and Will, 1981
			L+F Fine	38000	414	28	15	124	24	B 0.22 Zn 1.82 Cu 2.01 Mn 18.2	
			L+F Woody	11670	41	3	21	5		B 0.03 Zn 0.33 Cu 0.11 Mn 1.33	
NSW, Australia	Pinus radiata	3	Leaves Branches F+H	400 0 0							Forrest & Ovington, 1970
		5	Total Leaves Branches F+H	400 1800 0 0							
		7	Total Leaves Branches F+H	1800 4700 0 0							
		9	Total Leaves Branches F+H	4700 2600 2600 8900							

Table 5 Forest Floor Biomass and Nutrient Content

Location	Dom. Veg.	Age	Component/ Horizon	kg/ha							Reference
				Biomass	N	P	K	Ca	Mg	Other	
Central Sweden	Pinus sylvestris	120-140	L+F	6950	72	5.4	11.1	24.5	3.5 Na	9.57 S	Bringmark, 1977
		H	H	19900	160	10.7	18.5	45.7	11.2 Na	6.78 S	
Finland	Pinus sylvestris	28	H		1	3	20	45			Malkonen, 1975
		45	H		1	5	31	91			
		48	H		1	4	28	48			
Scotland, UK	Pinus sylvestris	33	Total		1622	78	165	322	31 Na	34	Ovington & Madgwick, 1959a
		23	Total		163	22	24	139	171 Na	3	
England, UK	Pinus sylvestris	55	Total		409	28	34	141	31	6	Ovington, 1959
		7	Total		15982	158.9	9.0	26.2	8.6 Na	.84	
England, UK	Pinus sylvestris	11		12144	116.6	7.1	11.0	47.5	7.0	1.08	Ovington, 1962 (summary)
		14		9875	90.7	6.8	11.7	63.3	5.8	1.22	
		17		17381	193.9	13.5	15.5	77.1	7.9	1.57	
		20		26370	376.0	21.0	23.3	127.5	11.4	2.57	
		23		29790	162.9	21.9	24.3	138.9	16.9	2.89	
		31		31527	285.2	19.1	31.5	122.5	16.3	3.79	
		35		36694	345.8	22.0	31.2	128.0	26.8	4.53	
		55		45011	408.7	27.6	34.4	141.4	30.7	6.47	
		47	Total		409	9	11	25	9 Na	2	
		46			274	15	24	67	15	3	
		17	L		26.4	4.0	2.7	16.6	3.1		
			F		132.5	16.9	9.9	42.3	8.5		
S. Carolina, USA	Pinus taeda	14	Total		15512	182	11.4	10.3	11.4		Wells et al, 1975
				15002	176	11.8	11.1	53.3	10.9		
Mississippi, USA	Pinus taeda	15-30	Total		17900	170	12	53	18		Switzer et al, 1979
		30-45		19000	180	11	15	85	20		
		45-100		20900	200	14	17	130	22		
		100-150		17800	210	13	18	180	23		
		150-240		14000	190	12	17	300	28		

kg/ha

Location	Dom. Veg.	Age	Component/ Horizon	Biomass	N	P	K	Ca	Mg	Other	Reference
N. Carolina, USA	Pinus taeda	16	Total		307	30	28	93	20		Wells & Jorgensen, 1975
N. Carolina, USA	Pinus taeda	50	L	3715	34.2			46.4			Wells & Davey, 1966
			F+H	19639	265.1			286.7			
	Pinus virginiana	40	L	2488	24.4			15.9			
			F+H	8722	99.4			56.7			
S. USA	Pinus taeda	20	Total		124	9	16	81	16	S 11	Switzer & Nelson, 1972
N. Carolina, USA	Pinus taeda	20	L	4721	36.8			16.5			Wells & Davey, 1966
			F	19392	306.4			77.6			
New Mexico, USA	Populus tremuloides	60	Total	28900	520						Vitousek et al., 1982
Alberta, USA	Populus tremuloides		L	11000	200	15	40	375	25		Lousier & Parkinson 1979
			F	21700	550	30	40	700	45		
			H	39900	900	50	130	1100	65		
			Ah	42200	475	30	350	300	60		
Minnesota, USA	Populus	40	Total		667		78	1081			Alban et al., 1978
Minnesota, USA	Populus	49	Total	20000	442	32	34	536	57		Persala & Alban, 1979
Alaska, USA	Populus (7 stands)	20-120	L	2829	38.2	4.0	5.4	60.0	6.8		van Cleve & Noonan, 1971
			F	8677	136.2	11.3	14.8	178.7	21.7	7	
			H	30517	476.1	45.8	64.1	402.8	79.3	2.7	
			Total	42023	650.5	61.0	84.2	641.5	107.8	30.2	
										33.6	
New Hampshire, USA	Prunus, Acer	3	Total	63900							Covington, 1976
	Prunus, Acer	4		56700	1480		71.4	347	74.8		
	Acer, Betula	7		59900							
	Acer, Prunus	11		52600							
	Acer, Betula	22		35300	950		45.5	317	43.8		
	Acer, Betula	30		60300							
	Acer, Fagus	35		58400							
	Acer, Fagus	40	Total	66800	1837		71.5	136	299		
	Acer, Sorbus	49		83100							
	Acer, Fagus	57		72500	1870		125	350	70.3		
	Acer, Fagus	200		89300	2402		86.6	446	50.0		

Location	Dom. Veg.	Age	Component/ Horizon	kg/ha							Other	Reference
				Biomass	N	P	K	Ca	Mg	S		
Washington, USA	Pseudotsuga (high site)	?	Total	17670	226	21	26					West et al. 1981 (preliminary data)
	Pseudotsuga (low site)	?	Total	13870	203	19	27					
Washington, USA	Pseudotsuga	300	Total	12000	110							Vitousek et al. 1982
Washington, USA	Pseudotsuga	53	Total	17600	214	20.9	25.9					Bigger & Cole, 1983
	high productivity low productivity			1390	187	18.8	27.1					
Washington, USA	Pseudotsuga	45	Total	18000	175							Vitousek et al. 1982
Washington, USA	Pseudotsuga	23	Total	21150	280							Binkley, 1982
Washington, USA	Pseudotsuga	25-41	Total	14000	150-							Bormann and DeBell 1981
	Pseudotsuga			25000	260							
Oregon, USA	Pseudotsuga		Total	22881	162	20	30	240	63	25		Youngberg, 1966
	+Holodiscus			28108	199	39	65	244	58	32		
	+Gaultheria			23348	173	32	31	205	74	24		
	+Acer cir.			21949	191	46	60	192	73	18		
	+Gaultheria			21703	287	40	32	236	70	29		
	+Acer cir.			32549	348	47	60	293	134	36		
	+Polystichum			29419	258	43	34	184	46	26		
	+Rubus			82185	1249	115	163	339	194	134		
	+Polystichum			63974	479	479	74	208	126	48		
	Pseudotsuga menziesii	95	Forest Floor	274		76.0	34.0	92.0	36.0			
Oregon, USA	Pseudotsuga menziesii	130		384		109.0	32.0	160.0	47.0			Grier (unpubl.) cited in Cole et al.,
	Pseudotsuga menziesii	450		445		62.0	80.0	619.0	160.0			
B.C., Canada	Pseudotsuga dry	120	L	5690								de Catanzaro, 1979
	Pseudotsuga dry		Total	45040								
	mesic		L	7100								
	moist		Total	45680								
	moist		L	4670								
			Total	25200								

Table 5 Forest Floor Biomass and Nutrient Content

70

Location	Dom. Veg.	Age	Component/ Horizon	Biomass	kg/ha					Other	Reference
					N	P	K	Ca	Mg		
Washington, USA	Pseudotsuga menziesii (plantation)	9	Forest floor		28	6.2	10.8	30.9	6.6		Turner, 1975
	Pseudotsuga menziesii (plantation)	30	Forest floor		223	30.3	44.1	129.5	53.6		
	Pseudotsuga menziesii (plantation)	49	Forest floor		272	38.0	51.0	203.0	46.0		
California, USA	Pseudotsuga	30		30887							Kittredge, 1940
Washington	Pseudotsuga menziesii	45	Total Control Low fert. High fert.	28700 31100 18600							Turner, 1977
England, UK	Pseudotsuga	21	Total		156	11	25	68	9	Na 3	Ovington, 1962 (summary)
		22			188	22	18	230	9	Na 6	
		47			119	7	9	27	7	Na 1	
	Larix dec.	46			594	25	23	104	27	Na 4	
	Betula	22			47	6	8	72	4	Na 1	
	Alnus	22			65	5	5	72	2	Na 1	
	Quercus	21			121	6	11	36	7	Na 1	
	Quercus	47			71	5	8	35	5	Na 1	
	Fagus	39			180	11	20	31	14	Na 1	
	Nothofagus	22			71	5	7	39	5	Na 1	
Oregon	Pseudotsuga menziesii	47			80	6	10	32	7	Na 1	
		450	Fallen logs	215000	215	7	24	153	16	Na 5	Sollins et al 1980
			Fine Litter	51200	256	50	56	445	133	Na 7	
			Soil org. matter	13300	3724	8	33	102	27	Na 2	
Washington, USA	Pseudotsuga	22	Wood	613	4	.4	.5	2.9	.7		Turner, 1975
			L	11406	73	14.4	21.3	50.6	30.5		
			H	8520	100	10.8	15.9	60.5	22.8		
		30	Wood	1396	11	.9	1.4	7.0	1.1		
			L	5850	46	7.2	9.6	47.1	10.2		
			H	9437	97	11.6	15.5	75.9	16.4		
		42	Wood								
			L	2410	20	2.9	3.8	15.1	3.5		
			H	14726	142	20.9	27.0	104.5	25.6		
		73	Wood	56372	219	21.7	35.0	233.1	19.2		
			L	10991	43	13.2	6.8	45.4	3.7		
			H	28372	312	34.2	34.8	185.1	43.8		
		95	Wood	37262	124	14.9	12.7	107.3			
			L	9210	87	9.3	12.8	65.3			
			H	34216	324	34.4	47.5	242.8			

Table 5 Forest Floor Biomass and Nutrient Content

Location	Dom. Veg.	Age	Component/ Horizon	kg/ha							Other	Reference
				Biomass	N	P	K	Ca	Mg			
Washington, USA	Pseudotsuga	450	L	14.4	3.2	4.8	34	2.3			Abee, 1973	
			needles	3.6	.4	.8	1.4	.5				
			cones	3.2			7	.4				
			twigs	1.2			1.7	.2				
			branches	2	.2	.3	2.4	.1				
			bark	.7	.1	.3	2.7	.2				
			hardwoods	1.5	.2	.3	.6	.1				
			moss, lichens	414	51	100	404	58	S 33			
			L + F + H	50874								
New Mexico	Pseudotsuga		Total	38200	269	28	338	800	119	S 59 Mn 16.2 Zn 3.6	Wollum, 1973	
	Pseudotsuga		Total	44500	286	27	232	804	171	S 54 Mn 18.9 Zn 3.9		
Washington USA	Pseudotsuga		Branches	1423	5	1	4	8			Cole et al., 1968	
			Needles	3005	35	4	5	27				
			Wood	6345	14	2	8	17				
			H	11999	121	19	15	85				
New Mexico, USA	Pseudotsuga, Abies	200	Total	82000	900						Vitousek et al., 1982	
B.C., Canada	Pseudotsuga, Tsuga	100+	L + F	27250	376	26	28	242	71		Binkley et al., 1982	
B.C., Canada	Pseudotsuga, Alnus rubra	23	Total	33600	502	61	18	238	50		Binkley, 1983, Binkley et al., 1984	
	Pseudotsuga, Alnus sinuata	23	Total	22100	282	72	16	160	51			
	Pseudotsuga,	23	Total	7000	36	45	6	31	17			
Korea	Quercus acutissima	12	L	6300	91	10	10				Mun et al., 1977	
New England, USA	Quercus	65	Total	58200	660						Vitousek et al., 1982	

Table 5 Forest Floor Biomass and Nutrient Content

Location	Dom. Veg.	Age	Component/ Horizon	kg/ha						Other	Reference
				Biomass	N	P	K	Ca	Mg		
Indiana, USA	Quercus	81	Total	19400	310						Vitousek et al. 1982
Minnesota, USA	Quercus		Total	4574	43.8	5.4		49.6	10.0		Reiners & Reiners, 1970
			Total	4687							
Tennessee, USA	Quercus alba	30-80	L	27000	334.0	22.0	26.0	517.0	32.0		Harris in Cole & Rapp, 1980
	Quercus prinus	30-80	L	25000	298.0	18.0	26.0	318.0	22.0		
N. Carolina, USA	Quercus alba		L	1912	26.8			27.9			Wells & Davey, 1966
			F+H	6809	116.4			147.1			
France	Quercus ilex	150	L	11400	124.7	4.0	10.2	361.2	19.7		Loissant, Rapp in Cole & Rapp, 1980
Belgium	Quercus mixed	115-160	L	5600							Duvigneud, Denaeve in Cole & Rapp, 1980
	Mixed decid.	80	L	4762	44.0	2.0	17.0	107.0	5.0		
Illinois, USA	Quercus-Carya	150	Xeric Total	5900	69	8	7	118	7		Rolfe, Akhtar & Arnold, 1978
		150	Mesic Total	6100							
Illinois, USA	Quercus-Carya-Liriodendron	70-100	Total	35762		1.8	4		3.2		Luvall, 1976
Mississippi, USA	Quercus, Carya, Pinus	early success middle success late success	Total		175	11	14	70	19	C-10000	Switzer et al. 1979
			Total		200	14	17	130	22	C-11300	
			Total		200	13	17	240	25	C-8600	
New England, USA	Quercus, Acer	50	Total	59600	845						Vitousek et al. 1982
California, USA	Sequoia	30	Total	27675							Kittredge, 1940
Minnesota, USA	Thuja, Fraxinus		Total	4115	45.0	6.5		87.0	11.5		Reiners & Reiners, 1970
			Total	4438							
	Thuja, Betula		Total	4881	42.0	6.2		90.6	12.0		
			Total	5634							

Table 5 Forest Floor Biomass and Nutrient Content

Location	Dom. Veg.	Age	Component/ Horizon	kg/ha						Other	Reference
				Biomass	N	P	K	Ca	Mg		
Oregon, USA	Tsuga heterophylla, Picea sitchensis	30	Forest floor		316.5	58.9	29.5	201.5	56.8		Grier (unpubl.) cited in Cole et al.
Oregon, USA	Tsuga heterophylla, Picea sitchensis	121	Forest floor		474.3	98.4	118.5	347.5	82.9		Grier (unpubl.) cited in Cole et al.
Oregon, USA	Tsuga mertensiana.	130	Forest floor		812.0	233.0	104.0	294.0	12.0		Grier (unpubl.) cited in Cole et al.
Washington, USA	Tsuga het. -mor	old	L F H	14431 22449 121004	162 313 1565	15 25 102	14 24 89				Gessal & Balc', 1965
Washington, USA	Tsuga, Picea	120	Total	21000	165						Vitousek et al., 1982
Japan	Varied lower slope mid slope upper slope		Total Total Total	100 120 200	6 6.9 10.6	10.8 14.4 21.9		87.4 77.8 107	13.9 13.6 19.6		Tsutsumi et al., 1978
USA (22 states avg)	Varied		Mull Mor	5371 6164	58.5 78.9			59.1 29.6			Mader, 1953

1 Mean values from two watersheds, based on 0.04ha. plots per watershed.

2 Mean as in 1 & includes large woody components eg down tree & branches as well as other O1 and O2 components.

Table 6 Forest Soil Nutrient Content

Location	Dominant Veg.	Age	Depth (cm)	Method	N	P	K	Ca	Mg	Other	Reference
California, USA Granitic Volcanic Sedimentary Acid Basic Ultrabasic			0-100		5490						Colwell, 1976
			0-100		5760						
			0-100		6580						
			0-100		4840						
			0-100		6340						
Washington, USA	Abies amab.	200	0-15	Total	878	2.2	72	44	26		Calculated from Vitousek et al. 1982
				NH ₄	3.9						
				NO ₃	0.1						
			15-30 30-70	Total	1170 4200	3.2 5.4	23 43	12 22	7 13		
B.C., Canada 1500m	Abies amab.		0-30		3976	400	105	102	32		Phiri, 1973
New England, USA	Abies balsamea	75	0-15	Total	6791	4.4	123	126	57		Calculated from Vitousek et al. 1982
				NO ₃	15						
				NO ₃	2.2						
			15-30	Total	1028	1.7	22	112	8		
New Hampshire,	Abies balsamea			NO ₄	5.2						
				NO ₃	0						
			0-30	Total		2165					
				Exch.	NH ₄ -24	222	2130	123	4190	Na Na 930	
Oregon, USA	Abies con.	23				-	87	110	26		Lang et al., 1981
			30-60	Total	1220	204	2350	243	6565	Na 121	
				Exch.	NH ₄ -14	-	81	59	9		
			60-90	Total	490	285	11840	1593	18750	Na 415	
Japan	Abies firma	97-145		Exch.	NH ₄ -13	-	313	23	8		Grier (unpubl.) cited Cole et al.
			Soil	Total N	1980	3212	240	90	240		
				Exch. Ca Mg K							
			Soil	Total N	2320	3212	240	240	90		
Japan	Abies firma	97-145		Exch. Ca Mg K							Ando in Cole & Rapp, 1980
			Root-zone		3389.0	5.0	368.0	278.0	143		

Table 6 Forest Soil Nutrient Content

Location	Dominant Veg.	Age	Depth (cm)	Method	N	P	K	Ca	Mg	Other	Reference
England, U.K.	Abies grand	45	0-70	Total	3390	7	577	2690	592	Na 89	Ovington, 1958
Colorado, USA	Abies lasio.		0-50	Total							Snell et al., 1979
Prince George, B.C. Canada	Abies lasio.	110-300	Urg. Layer	Total	842	74	96	344	55		Kimmins, 1974
			Exch.				106	263	47		
			Min. Horizons								
			-To sampled depth	Total	4395	6243	6373	6713	22846		
			Exch.				330	893	142		
			-In root zone	Total	3605	4492	4378	3829	13463		
			Exch.				224	653	117		
			-In top 30cm	Total	2546	2979	2410	1906	5824		
			Exch.				144	479	89		
			Total to 1m.	Total	5237	6317	6469	7057	22901		
			Exch.				436	1156	189		
			Total rooting zone	Total	4451	4566	4474	4173	13518		
			Exch.				350	916	164		
			Total in zone of max. rooting	Total	3388	3053	2506	2250	5879		
			Exch.				250	742	139		
Oregon, USA	Abies nobilis	130	Soil	Total N	14000	23	1000	800	178		Grier (unpubl.) cited in Cole et al.
			Extract. P								
			Exch. Ca Mg K								
Indiana, USA	Acer, Fagus, Quercus	95	0-15	Total N	1837	51	107	1194	88		Calculated from Vitousek et al., 1982
			NH ₄ F-P NH ₄	4.1							
			Extr. cations								
			NH ₄	2.2							
			Total	1210	31	129		352	53		
			NH ₄	5.8							
			NH ₄	1.5							
			Total	2852	2.9	417		1996	299		
			NH ₄	14.6							
			NH ₄	5.3							
New England, USA	Acer, Fagus, Betula	66	0-15	Total	3348	0.8	46	39	14		Calculated from Vitousek et al., 1982
			NH ₄	4.9							
			NH ₄	1.1							
			Total	2280	1.1	52		67	16		
			NH ₄	3.8							
			NH ₄	0.9							
			Total	2346	9.7	80		117	18		
			NH ₄	no value							
			NH ₄	no value							

Table 6 Forest Soil Nutrient Content

Location	Dominant Veg.	Age	Depth (cm)	Method	N	P	K	Ca	Mg	Other	Reference
20-50					3590	323	483	1380	290	Zn 12.7	
										S 428	
										SO4S 174	
										Fe 127	
31	0-20				3330	73	293	568	110	Mn 50	
										Cu 2.5	
										Zn 24.8	
										S 311	
20-50					2330	76	277	443	91	SO4S 27	
										Fe 89	
										Mn 54	
										Cu 1.6	
38	0-20				3590	200	442	1140	236	Zn 4.4	
										S 402	
										SO4S 140	
										Fe 54	
20-50					3800	192	459	1130	235	Mn 35	
										Cu 0.8	
										Zn 2.6	
										S 336	
42	0-20				3170	266	436	1050	197	SO4S 0	
										Fe 117	
										Mn 75	
										Cu 2.7	
20-50					3740	283	470	1270	299	Zn 9.0	
										S 464	
										SO4S 164	
										Fe 124	
44	0-20				3170	266	436	1050	197	Mn 78	
										Cu 2.9	
										Zn 14.3	
										S 270	
20-50					3740	283	470	1270	299	SO4S 0	
										Fe 120	
										Mn 67	
										Cu 2.5	
45	0-20				4000	187	294	400	58	Zn 9.5	
										S 481	
										SO4S 134	
										Fe 144	
20-50					3850	154	435	674	133	Mn 72	
										Cu 2.7	
										Zn 16.0	
										S 386	
20-50					3850	154	435	674	133	SO4S 50	
										Fe 108	
										Mn 44	
										Cu 2.3	
20-50					3850	154	435	674	133	Zn 24.3	
										S 784	
										SO4S 337	
										Fe 112	
20-50					3850	154	435	674	133	Mn 59	
										Cu 2.4	
										Zn 11.8	

Table 6 Forest Soil Nutrient Content

Location	Dominant Veg.	Age	Depth (cm)	Method	N	P	K	Ca	Mg	Other	Reference
Washington, USA	Alnus rubra	40	0-15	Total	1920	6.8	112	787	104		Calculated from Vitousek et al. 1982
				NH ₄	3.4						
				NO ₃	0.8						
Washington, USA	Alnus rubra	23	15-30 30-70	Total	765	7.8	60	444	55		Calculated from Binkley, 1982
				Total	2376	6.5	232	891	178		
				Total N Exch. cations Walkley-Black C	5565	114	176	176	20	C 98.100	
Washington, USA	Alnus rubra	34	Root-zone	Total	5454						
Alaska, USA	Betula papyrif.		Root-zone		2879.0	26.2	186.0	7547.7	2317.1	Org. Mat. 280100	Turner et al., 1976
England, U.K.	Betula alb.	21	0-70			230	125	7105	156	Na 88	Van Cleve in Cole & Rapp, 1980
N. Carolina, USA	Betula lut. Betula lut.	40-60 >100	A1-B1	Avail.		23 24	229 112	148 57	64 26		Ovington, 1958 Weaver, 1975
England, U.K.	Castanea sat.	45	0-70			39	239	424	265	Na 59	Ovington, 1958
B.C., Canada	Ceanothus. Pseudotsuga	14	0-15	Total N Exch. cations	1130	54	1510	110			Binkley & Husted, in review
England, U.K.	Chamaecyparis	20	0-60			4	152	292	215	Na 111	Ovington, 1958
Shiga, Japan	Chamaecyparis				10640	21.4	884	305	42.3		Kawahara, 1971
England, U.K.	Coppice	20	0-60			4	208	326	211	Na 93	Ovington, 1958
Japan	Cryptomeria	1	0-20	Total		12921	4318		13183		Kawana et al., 1979
				Exch.		559	2000		151		
		3	0-20	Total		3719	6489		6229		
				Exch.		208	1018		132		
		5	0-20	Total		5506	3320		8025		
				Exch.		262	656		88		
		7	0-20	Total		5794	3239		8257		
				Exch.		187	331		38		
		9	0-20	Total		2200	1933		3731		
				Exch.		127	211		31		
		12	0-20	Total		4915	3057		3772		
				Exch.		263	610		65		
		22	0-20	Total		5004	3112		5901		
				Exch.		155	690		40		

Table 6 Forest Soil Nutrient Content

Location	Dominant Veg.	Age	Depth (cm)	Method	N	P	K	Ca	Mg	Other	Reference
S.W. Western Australia	<i>E. diversicolor</i>	36	0-90	Total	7439	1718	6214	10224	5346	S 2906	Mingston et al. 1979
				extract.		842	471	3827	1027	S 260	
										Na 179	
Maroondah, Victoria, Australia	<i>E. diversicolor</i> <i>E. calophylla</i>	all	0-90	Total	4442	5351	58314	11754	10680	S 2826	Feller, 1980 unpublished data
				extract.		4195	382	3783	1224	S 377	
										Na 275	
Stradbroke Is. Queensland, Australia	<i>Eucalyptus regnans</i> <i>Eucalyptus obliqua</i> <i>E. dives</i>	38	0-100	Total	17278	3295					Westman & Rogers 1977
				extract.		260					
				Total	13443	1704	825	1031	347	Na 536	
Kyoto, Japan	<i>Fagus cren.</i> <i>Fagus sylv.</i> <i>Fagus sylv.</i>	?	0-14 14-110 110-191	Total N	3038	3	24	99	43	Na 74	Kawahara, 1971
				Others							
				extract.	14865 14854	15 46	141 103	214 193	262 226	828 1170	
England, U.K. Germany	<i>Fagus sylv.</i>	45	0-70		11472	31.6	399	275	22.1		Ovington, 1958
						42	254	365	249	Na 47	
				root-zone	9452 7340	2310 2870	550 387	280 268	45 40	Org. Mat. 212000 190000	
Soliling, W. Germany	<i>Fagus sylv.</i>	125	0-10 10-20 20-30 30-40 40-50 0-10 10-20 20-30 30-40 40-50	Total	2530	645	17300	2200	1700		Ulrich et al. 1974 Ulrich et al. 1979
					1450	535	20200	1600	2300		
					1310	580	n.d.	n.d.	n.d.		
					1200	590	23400	2500	4000		
					840	520	23700	2200	4300		
				Exch.			87	109	10.3		
							69	51	5.2		
							88	48	4.9		
							91	43	4.7		
							118	36	5.1		
Sweden	<i>Fagus sylv.</i>	45-130	Root-zone		7800	38	56	175	84	Org. Mat. 207000	Nihlgard in Cole & Rapp, 1980
New Hamp. USA	Hardwood			Total	3600						Bormann et al. 1977
England, U.K.	<i>Larix dec.</i>	45	0-70		463	223		404	254	Na 64	Ovington, 1958
England, U.K.	<i>Larix eur.</i>	20	0-60		4	154		360	204	Na 77	Ovington, 1958

Table 6 Forest Soil Nutrient Content

Location	Dominant Veg.	Age	Depth (cm)	Method	N	Content kg/ha			Ca	Mg	Other		Reference
					P	K							
England, U.K.	Larix lep.	21	0-70		329	115	17720	296	Na	158			Ovington, 1958
Montana, USA	Larix, Pseudotsuga		0-50	Total	11420	16210	200000	52400	53300		Cu 280 Fe 300000 Mn 11500 Na 66800 Zn 2630		Stark 1979
				Exch.		11440	1700	8570	890		Cu 28 Fe 300 Mn 440 Na 150 Zn 9		
Tennessee, USA	Liriodendron	50	Root-zone		7650.0	2840.0	38960.0	8130.0			Org. Mat 159000		Harris in Cole & Rapp, 1980
Tennessee, USA	Liriodendron, 30-Carya, Quercus	80	Root-zone		7300.0	1400.0	36000.0	6300.0	8700		Org. Mat 189000		Harris in Cole & Rapp, 1980
Japan	Lower slope Upper slope		Total		8560 2720	430 116	1140 34	391 11					Katagiri & Tsutsumi, 1976
Japan	Mixed		0-70		6762	13.5	203	30.3	57.2				Katagiri et al., 1978
Kyoto, Japan	Mixed broad Chamaecyparis		0-70	Total	3701 2143	5779 2640	258 194	3842 2165					Iwatsubo, 1976
Great Britain	Mixed decid.	80	Root-zone		1512.0	1543.0	1766.4	81.5			Org. Mat. 138000		Satchell in Cole & Rapp, 1980
Tennessee, USA	Mixed hardwood		0-45	Total Exch.	3380 4	52000 260	8800 960						West et al., 1981 (prelimin. data)
England, U.K.	Nothofagus	20	0-60		3	156	344	278	Na	106			Ovington, 1958
England, U.K.	Open (3)		0-60		3	200	420	214	Na	66			Ovington, 1958
Minnesota, USA	Picea	40	0-10 10-36	Total N Exch. K Total Ca	1608 934 3744	104 195 630	1451 1357 5016						Alban et al., 1978
Minnesota, USA	Picea	41	0-10 10-25 25-36 36-61	Total N Exch. cations	1257 640 236 497	20 50 26 43	1014 598 300 1145	109 101 51 200					Perala & Alban 1979

Table 6 Forest Soil Nutrient Content

Location	Dominant Veg.	Age	Depth (cm)	Method	Content kg/ha					Other	Reference
					N	P	K	Ca	Mg		
Sweden	Picea	59	A	Total	800	41					Tamm, 1969
					1200+	250+					
					470	63					
Sweden	Pinus	76	A	Total	530	2					Tamm, 1969
					520	500					
Nova Scotia.	Picea abies	All	0-30	Total Exch.	3860	1220	13300	5460	1740		Freedman et al. 1981
					NH4-35	105	61	77	30		
					NO3-10						
England, U.K.	Picea abies	20	0-60	Total		5	147	293	227	Na 68	Ovington, 1958
England, U.K.	Picea abies	45	0-70	Total		210	236	466	314	Na 78	Ovington, 1958
Sweden	Picea abies	60	Root-zone	Total	6900.0	146.0	65.0	150.0	31.0	Org. Mat. 207000	Nihlgard, 1972
Solling, W. Germany	Picea abies	85	0-10	N, P Total	2400	560	103	100	11.5		Ulrich et al., 1974, 1979
					1570	500	96	51	6.6		
					1100	495	46	35	3.8		
					940	530	60	24	3.3		
					860	505	67	45	5.1		
Sweden	Picea abies	65-132	0-5	K, Ca, Mg Exch.	491	270	5800	3300	900	Na 3600	Nykqvist 1977
										Mn 99	
										Na 3500	
										Mn 104	
										Na 2000	
										Mn 102	
										Na 3400	
										Mn 93	
										Na 2700	
										Mn 99	
Germany	Picea abies	34-115	5-10	Total	382	305	5700	4300	1000	Na 4300	Ulrich in Cole & Rapp, 1980
										Mn 127	
										Na 7900	
										Mn 228	
										Na 9800	
										Mn 235	
										Org. Mat. 190000	
										35.0 190000	
										38.0 251000	
Germany	Picea abies	34-115	10-15	Total	354	303	4900	3300	800	Na 2000	Ulrich in Cole & Rapp, 1980
										Mn 102	
										Na 3400	
										Mn 93	
										Na 2700	
										Mn 99	
										Na 4300	
										Mn 127	
										Na 7900	
										Mn 228	
Germany	Picea abies	34-115	15-20	Total	325	353	5700	3600	900	Na 3400	Ulrich in Cole & Rapp, 1980
										Mn 93	
										Na 2700	
										Mn 99	
										Na 4300	
										Mn 127	
										Na 7900	
										Mn 228	
										Na 9800	
										Mn 235	
Germany	Picea abies	34-115	20-25	Total	360	412	5700	2900	900	Na 3600	Ulrich in Cole & Rapp, 1980
										Mn 99	
										Na 3500	
										Mn 104	
										Na 2000	
										Mn 102	
										Na 3400	
										Mn 93	
										Na 2700	
										Mn 99	
Germany	Picea abies	34-115	25-30	Total	389	393	7700	4800	1500	Na 4300	Ulrich in Cole & Rapp, 1980
										Mn 127	
										Na 7900	
										Mn 228	
										Na 9800	
										Mn 235	
										Org. Mat. 190000	
										35.0 190000	
										38.0 251000	
Germany	Picea abies	34-115	30-40	Total	504	778	13900	8300	2400	Na 4300	Ulrich in Cole & Rapp, 1980
										Mn 127	
										Na 7900	
										Mn 228	
										Na 9800	
										Mn 235	
										Org. Mat. 190000	
										35.0 190000	
										38.0 251000	
Germany	Picea abies	34-115	40-50	Total	424	750	14500	9800	3100	Na 4300	Ulrich in Cole & Rapp, 1980
										Mn 127	
										Na 7900	
										Mn 228	
										Na 9800	
										Mn 235	
										Org. Mat. 190000	
										35.0 190000	
										38.0 251000	

Table 6 Forest Soil Nutrient Content

82

Location	Dominant Veg.	Age	Depth (cm)	Method	N	Content kg/ha				Reference
						P	K	Ca	Mg	
Alaska, USA	Picea mariana	51	Root-zone		2689.0	2.0	124.0	1691.0	853.8	Org. Mat. 3951.0 Cole & Rapp, 1980
		55			2198.0	5.4	169.0	609.0	121.0	
		130			2362.0	4.4	286.0	5052.0	912.0	
Quebec, Canada	Picea mariana Picea rub.	65	0-35 0-35	Total	296 559					Weetman & Webber 1972
England, U.K.	Picea oko.	20	0-60			3	144	282	216	Ovington, 1958
Sweden	Picea on sphagnum	60	root depth		8600	220	140	5800	109	Holmen, 1964
New Mexico, USA	Picea, Abies	300	0-20 20-40	Total Total	4060 2058	1.4 0.6	106 57	407 118	33 7	Calculated from Vitousek et al. 1982
				NH ₄	4.1					
				NO ₃	0.1					
N. Carolina, USA	Picea, Abies	40-60	A1-B2	Avail.		9	80	81	30	Weaver, 1975
Minnesota, USA	Pinus banks.	41	0-10 10-25 25-36 36-61	Total N Exch. cations	1382 666 270 558	26 46 20 39	99 107 70 161	1497 977 459 1195	138 131 69 192	Perala & Alban 1979
			0-10 10-36	Total N Exch. K	1502 810	94 187	2080 1722			
				Total Ca	3314	477	4840			
Minnesota, USA	Pinus banks.	40	Shallow Deep	Total Total	3194 5554	23 495	126 500	317 1727	56 289	Alban et al., 1978
Ontario, Canada	Pinus banks.	65	to 8f2 Total	Avail Total	2920 15	2152 6	80637 539	34406 172	21075 37	Green & Grigal, 1979 (From White & Harvey 1979)
			Org. Horizons	Total Exch.	352 Exch.	39	42 42	76 57	18 12	
			Min. Horizons	Total Exch.	2073 Exch.	4418 179	3532 179	3068 525	12387 56	
Prince George, B.C. Canada	Pinus con.	110- 125	-In root zone	Total Exch.	1299 Exch.	2309 81	1867 81	1235 222	4997 22	Morrisson & Foster, 1979
			-In top 30cm (zone of max. rooting)	Total Exch.	917 Exch.	1498 43	955 43	496 104	43 10	
			Total sampled depth	Total	2424	4457	3574	3144	12405 t4	
Exch.			Total in rooting zone	Total Exch.	1651 Exch.	2348	1909 123	1311 279	5015 34	Exch.

Table 6 Forest Soil Nutrient Content

Location	Dominant Veg.	Age	Depth (cm)	Method	N	P	K	Ca	Mg	Other	Reference
			Total in zone of max. rooting								
			Total	Exch.	1269	1498	997	572	1977		
						85	161		22		
Kyoto, Japan	Pinus densl.				5056	8.4	206	180	13.8		Kawahara, 1971
Japan	Pinus densl.			N Total	588	16.1	126	205	82.1	Na 47.1	Nishimura, 1973
				Others HCL							
Indiana, USA	Pinus echin.	33	0-15	Total	1112	14	95	953	133		Calculated from Vitousek et al. 1982
				NH4	1.6						
				NO3	0.5						
			15-30	Total	684						
				NH4	2.7						
				NO3							
			0.3								
			30-70	Total	1359	4	706	3442	1087		
				NH4	6.3						
				NO3	0.2						
Tennessee, USA	Pinus echinata	30	Root-zone		4100.0	1200.0	38000.0	3600.0	10900.0	Org. Mat. 116000	Harris in Cole & Rapp, 1980
England, U.K.	Pinus nigra	20	0-60		3	242		770	437	Na 120	Ovington, 1958
England, U.K.	Pinus nigra	45	0-70		59	359		473	269	Na 79	Ovington, 1958
England, UK	Pinus nigra	21	0-70		314	66		22865	182	Na 127	Ovington, 1958
Scotland	Pinus nigra	40	105	Total	701						Miller, Miller & Pauline 1976
New Zealand	Pinus on Pumice soil		0-15	Truog P	22.4	291		259	50		Knight & Will 1970
			15-45	Exch. others	4.5	725		167	17		
			47-75		7.8	933		131	19		
			75-135		10.1	1236		306	9		
			135-165		5.6	781		613	62		
			165-200		3.4	202		1584	192		
			Total		53.8	4169		3060	348		
Sweden	Pinus on sphagnum	44	root depth		1000	60	60	300			Holmen, 1964
New Mexico, USA	Pinus pond.	200	0-10	Total	790	2.1	231	1028	95		Calculated from Vitousek et al. 1982
				NH4	2.1						
				NO3	0.1						
			10-20	Total	568	1.1	133	841	95		
				NH4	1.1						
				NO3	<.1						
			20-40	Total	394	0.8	77	947	166		
				NH4	0.8						
				NO3	0.2						

Table 6 Forest Soil Nutrient Content

Location	Dominant Veg.	Age	Depth (cm)	Method	N	P	Content kg/ha		Ca	Mg	Other	Reference
								K				
New Zealand	Pinus rad.	10	100	Total(HCl) Avail.	1042 414	2240 1232	2016 549					Will, 1966
New Zealand	Pinus rad. -lupins Pinus rad. +lupins	4	0-100	Total	1143							Gadgill, 1976
New England, USA	Pinus res.	50	0-15	Total NH ₄ NO ₃	2488 1.3 0.2	1.1	37	57	11			Calculated from Vitousek et al. 1982
			15-30	Total	1074	0.6	47	24	14			
			30-70	Total NH ₄ NO ₃	1487 3.0 0.4	0.7	145	74	45			
Minnesota, USA	Pinus res.	40	0-10 10-36	Total N Exch. K Total Ca	1894 856 3736	112 191 600	2187 1716 4942					Alban et al. 1978
Minnesota, USA	Pinus res.	41	0-10 10-25 25-36 36-61	Total N Exch. cations Total Ca	1117 611 242 471	23 50 25 48	87 80 51 114	1387 830 350 867	112 31 53 139			Perala & Alban 1979
N. Carolina, USA	Pinus strob. Mixed dec.	14	30 30	Total		153-260 135-241	627-1231 170-499	150-505 130-273				Yount, 1975
England, U.K.	Pinus sylv.	45	0-70	Total N	780	107	249	473	299	Na 57		Ovington, 1958
Central Sweden	Pinus sylv.	120-150	0-20	Total N		-	46	91	18	Na 8.3		Bringmark, 1977
Finland	Pinus sylv.	28	Humus 0-10 10-20 20-30 Total		1.0 3.0 3.0 4.0 11.0	3.0 9.0 6.0 6.0 24.0	20.0 32.0 18.0 16.0 86.0	45.0 42.0 44.0 36.0 167.0				Malonen, 1974
		45	Humus 0-10 10-20 20-30 Total		1.0 5.0 5.0 7.0	5.0 9.0 3.0 2.0	31.0 37.0 26.0 17.0	91.0 113.0 60.0 44.0				
		48	Humus 0-10 10-20 20-30 Total		18.0 1.0 5.0 4.0 5.0	19.0 4.0 7.0 3.0 21.0	111.0 28.0 30.0 14.0 12.0	308.0 48.0 33.0 19.0 84.0				

Table 6 Forest Soil Nutrient Content

Location	Dominant Veg.	Age	Depth (cm)	Method	Content kg/ha				Reference
					N	P	K	Other	
N. Carolina, USA	Pinus taeda	16	0-70		1753	371	404		Wells et al., 1975
New Mexico, USA	Populus tremuloides	60	0-10	Total	1414	1.3	207	28	Calculated from Vitousek et al., 1982
				NH ₄	7.3				
			10-20	Total	977	1.1	289	49	
				NH ₄	3.2				
Minnesota, USA	Populus	40	0-10	Total	1313				Alban et al., 1978
			10-36	Exch. K.	745				
				Total Ca	3197				
Minnesota, USA	Populus	49	0-10	Total N	1093	24	87	100	Peralta & Alban 1979
			10-25	Exch. cations	600	42	78	95	
			25-36		247	23	49	51	
			36-61		529	51	116	148	
Oregon, USA	Pseudotsuga menziesii	450	Root-zone		4560.0	34.0	660.0	2040.0	Grier in Cole & Rapp, 1980
Washington, USA	Pseudotsuga menziesii	42	Root-zone		2476.0		209.5	661.0	Turner in Cole & Rapp, 1980
Washington, USA	Pseudotsuga menziesii (plantation)	9	Soil	Total N	2907	141	286	837	Turner 1975
	Pseudotsuga menziesii	22	Exch. Ca Mg K	Exch. Ca					
			Soil	Total N	2809	141	741	109	
	Pseudotsuga menziesii	30	Exch. Ca Mg K	Exch. Ca					
			Soil	Total N	2809	141	234	741	
	Pseudotsuga menziesii	30	Exch. Ca Mg K	Exch. Ca					
			Soil	Total N	2907	141	286	837	
	Pseudotsuga menziesii (plantation)	42	Exch. Ca Mg K	Exch. Ca					
			Soil	Total N	2809	141	234	741	
	Pseudotsuga menziesii	49	Exch. Ca Mg K	Exch. Ca					
			Soil	Total N	2907	141	286	837	
	Pseudotsuga menziesii	73	Exch. Ca Mg K	Exch. Ca					
			Soil	Total N	2809	141	234	741	
	Pseudotsuga menziesii	95	Exch. Ca Mg K	Exch. Ca					
			Soil	Total N	2809	141	234	741	

Table 6 Forest Soil Nutrient Content

Location	Dominant Veg.	Age	Depth (cm)	Method	Content kg/ha				Other	Reference
					N	P	K	Ca		
Oregon, USA	Pseudotsuga menziesii	95	Soil	Total N	10000	160	1500	6000		Grier (unpubl.) cited in Cole et al.
			Exch. Ca	Mg K						
	Pseudotsuga menziesii	130	Soil	Total N	8000	20	1000	2400		
			Exch. Ca	Mg K						
Washington, USA	Pseudotsuga	23	0-50	Total N	4650		103	241		Calculated from Binkley, 1982
				Exch. cations						
England, U.K.	Pseudotsuga	20	0-60			4	199	475		Ovington, 1958
				Walkley-Black C						
Washington, USA	Pseudotsuga	36	0-15		809	1167	79	313		Cole et al., 1967
			15-30		868	1195	66	196		
			30-45		761	980	52	152		
			45-60		371	536	37	80		
				Total	2809	3878	234	741		
			0-15		860	1230	83	400		
			15-30		820	1110	66	210		
			30-45		710	1040	53	100		
			45-60		400	520	42	110		
				Total	2790	3900	244	820		
Oregon, USA	Pseudotsuga	450	0-15		780					Binkley et al., 1982
			15-30		600					
			0-15		710					
			15-30		540					
			0-15		1060					
			15-30		820					
			0-15		790					
			15-30		700					
			0-15		1230					
			15-30		830					
B.C., Canada	Pseudotsuga	31	0-15		1330					Calculated from Binkley, 1982
			15-30		990					
			0-50	Total N	1560	24	140	465		
				Bray P						
				Exch. K						
				Walkley-Black C						
			0-15		780					
			15-30		600					
			0-15		710					
			15-30		540					
B.C., Canada	Pseudotsuga	14	0-15	Total N	630	38	430	38		Binkley & Husted, 1983
				Exch. cations						
England, U.K.	Pseudotsuga	45	0-70		50	253	534	285		Ovington, 1958

Table 6 Forest Soil Nutrient Content

Location	Dominant Veg.	Age	Depth (cm)	Method	N	P	K	Ca	Mg	Other	Reference
B.C., Canada	Pseudotsuga,	23	0-50	Total N	1900	33	182	822	126	C 41,080	Binkley et al. 1984
	Alnus sinuata			Bray P							
England, U.K.	Quercus	45	0-70			54	213	343	254	47	Ovington, 1958
	Quercus	81	0-15	Total	1762	71	159	217	49		Calculated from Vitousek et al. 1982
Indiana, USA				NH ₄	2.9						
				NO ₃	0.5						
			15-30	Total	890	416	214	64			
				NH ₄	9.3						
				NH ₃	0.9						
			30-70	Total	3121	184	25	1997	749		
				NH ₄	26.2						
				NO ₃	1.2						
Korea	Quercus acutissima	12	0-35	Total N	4560	46	1720				Mun et al. 1977
Belgium	Quercus	115-		Exch. P+K							
	Quercus-mixed	160	Root-zone		13800	2100	767	13855	1007	Org. Mat. 300000	Duvigneud-Denaeyer in Cole & Rapp, 1980
England, U.K.					4480	920	157	13600	151	220000	
			0-60			3	141	269	192	54	Ovington, 1958
England, U.K.	Quercus rob.	45	0-70			36	329	424	301	70	Ovington, 1958
England, U.K.	Quercus rub.	20	0-60			4	110	238	156	52	Ovington, 1958
New England, USA	Quercus, Acer rubrum	55	0-15	Total	3319	1.6	45	92	14		Calculated from Vitousek et al. 1982
				NH ₄							
				NO ₃	0.2						
			15-30	Total	1332	0.7	43	44	13		
				NH ₄	4.7						
				NO ₃	0.1						
			30-70	Total	1725	1.0	135	69	41		
				NH ₄	3.8						
				NO ₃	0.3						
New England, USA	Quercus, Pinus	65	0-15	Total	676	0.8	53	27	16		Calculated from Vitousek et al. 1982
				NH ₄							
				NO ₃	0.1						
			15-30	Total	312	0.3	61	31	19		
				NH ₄	1.7						
				NO ₃	0.3						
			30-70	Total	1490	0.5	194	99	60		
				NH ₄	4.5						
				NO ₃	0.5						

Table 6 Forest Soil Nutrient Content

Location	Dominant Veg.	Age	Depth (cm)	Method	N	P	K	Ca	Mg	Other	Reference
Tennessee, USA	Quercus, Carya	30-80	Root-zone		4700	1200	38000	3600	10900	Org. Mat 116000	Harris in Cole & Rapp, 1980
England, U.K.	Thuja plicata	20	0-60			3	150	258	191	63	Ovington, 1958
Oregon, USA	Tsuga heterophylla Picea sitchensis	30	Soil Exch. Ca Mg K	Total N Extract. P	32900	70	675	1600	1900		Grier (unpubl.) cited in Cole et al.
	Tsuga heterophylla Picea sitchensis	121	Soil Exch. Ca Mg K	Total N Extract. P	34900	100	720	1600	1900		
Oregon, USA	Tsuga mertensiana	130	Soil Exch. Ca Mg K	Total N Extract. P	5200	18	220	280	70		Grier (unpubl.) cited in Cole et al.
Japan	Tsuga sieboldii	120-443	Root-zone		2732.0	1.3	62.0	49.0	21.0		Ando in Cole & Rapp, 1980
Oregon, USA	Tsuga heter.	120	0-15 15-30 30-70	Total NH ₄ NO ₃ Total	8754 8.1 3.1 7554 17929	57.7 27.2 0.4	423 79 125	746 262 448 384	822 218		Calculated from Vitousek et al. 1982
England, U.K.	Tsuga heter.	20	0-60			4	105	279	177	78	Ovington, 1958
Washington, USA	Tsuga heter.		0-122		9160						Heilman, 1979
Washington, USA	Tsuga heter.		0-152		14380						Heilman, 1979
B.C., Canada	Tsuga, pseudotsuga	Various	0-80	Total N Exch. Cations Extract P.	6630	95	350	6550	390		Klinka et al. 1981
		0-70			4570	18	87	500	40		
		0-65			4650	16	150	330	25		
		0-60			5700		1400	3690	1730		
		0-35			9380		760	4520	2052		
		0-75			3030		590	2100	220		
		0-75			3300			1800	425		
		0-60			4700		310	4025	1030		
		0-95			11100	14	520	7120	1590		
		0-90			6900	21	200	1920	60		

Table 6 Forest Soil Nutrient Content

Location	Dominant Veg.	Age	Depth (cm)	Method	N	P	K	Ca	Mg	Other	Reference
England, U.K.	Unplanted		0-70			414	152	8560	163	91	Ovington, 1958
Japan	Varied		0-70	Exch.	8670	27.9	236.2	1933	447		Tsutsumi et al 1978
	lower slope				7480	34.3	237.7	552	216.9		
	mid				5870	258.2	258.6	518	111.7		
	upper										

Table 7 Litterfall Biomass & Nutrients

Location	Dom. Veg.	Age	Component	Biomass	kg/ha/yr					Reference
					N	P	K	Ca	Mg	
Kochi, Japan	Abies		Total	5339	45.1	2.78	20.86	46.99	7.03	Ando et al. 1977
New York, USA	Abies bals.	25	Leaves	2900	34.4	2.5	3.3	30.9	4.4	Chandler, 1943
Japan	Abies firma	97-145	Overstorey	5376	31.6	1.9	11.4	37.0	4.7	Ando in Cole & Rapp, 1980
New England, USA	Abies, Betula	75	Total	4020	62					Vitousek et al. 1982
USSR	Abies, Quercus		Total ash	287						Utenkova, 1962 ¹
	Abies		Herb. ash	36						Utenkova, 1962 ¹
			Total	120						
			Herb. ash	48						
Washington, USA	Abies, Tsuga	200	Total	2180	12					Vitousek et al. 1982
New York, USA	Acer sac. & mix	30-70	Leaves	2900	15.2	3.0	12.6	45.8	5.8	Chandler, 1941
Montreal, Canada	Acer sac.		Leaves	3400						Coldwell & de Long, 1950 ¹
New York, USA	Acer sac. & others	30-70	Leaves	3300	16.9	3.45	9.4	73.6	11.7	Chandler, 1943
Conn., USA	Acer sac. & mix		Total	2100						Scott, 1955
N. Hampshire, USA	Acer, Betula, Fagus	110	Overstorey	5860	54.2	4.0	18.3	40.7	5.9	Whittaker in Cole & Rapp, 1980
New England, USA	Acer, Fagus, Betula	66	Total	4780	64					Vitousek et al. 1982
Indiana, USA	Acer, Fagus, Quercus	95	Total	5230	48					Vitousek et al. 1982
N. Hampshire	Acer, Fagus, Betula	uneven	Total	5702	54.2	4.0	18.3	40.7	5.9	Gosz et al. 1972
			Branches	1193	10.4	.9	1.7	11.1	.9	
			Limbs	74	.1	0.0	0.0	0.1	0.1	
			Trunks	805	.6	.0	.3	.9	.1	
			Bark	97	.7	.0	.1	.7	.0	
			Hard. fol.	2692						
			+Con. fol.	108	29.9	1.9	12.6	23.3	3.8	
			Bud scales	85	1.2	.1	.2	.7	.1	
			Flowers	23	.8	.0	.0	.1	.0	
			Fruit	165	2.8	.3	1.4	.8	.2	
			Fruit	180	2.5	.1	1.0	.9	.2	
			Fruit	166	3.7	.4	1.1	1.1	.1	
			Misc.	66	.6	.3	.3	.7	.2	
			Shrubs	66	.6	.3	.3	.7	.2	
			Herbaceous	48	9.0	.1	.3	.3	.3	

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0.2 0.0 0.0
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Table 7 Litterfall Biomass & Nutrients

Location	Dom. Veg.	Age	Component	Biomass	kg/ha/yr					Ca	Mg	Other	Reference
					N	P	K						
Toronto, Canada	Acer, Quercus	60-200	Total	4300									Bray & Gorham, 1964
			Leaves	3100									
			Stem, bark	1300									
			Ash	361									
B.C., Canada	Alnus rubra	23	Non-woody	5710	132	5.3	16			51	10		Binkley, 1983
	Pseudotsuga		Woody	675	5	0.1	0.3			3	0.3		
Washington, USA	Alnus rubra	40	Total	4900	90								Vitousek et al., 1982
B.C., Canada	Alnus rubra	18	total	7740	168	12	18			102	21		Binkley et al., 1982
Washington, Korea	Alnus rubra	30	Overstory	3700	87.0	6.2	39.0			67.0	10.0		Turner, 1975
	Alnus sibirica	12	Total	5120	89.0	8.9	59.0						Mun et al., 1977
B.C., Canada	Alnus sinuata	23	Non-woody	3840	112	6.1	15			37	12		Binkley et al., 1984
	Pseudotsuga		Woody	1370	9	0.4	0.6			7	0.6		
Juneau, Alaska	Alnus, Sal.	12-30	Total	2533									Hurd, 1971
			Non-wood	1827									
Kunadacs, Hungary	Betula	30	Total	3600									
Vesijako, Finland	Betula	91	Total	1800									Viro, 1955
			Leaves	1300									
			Other	500									
Veldre, Norway	Betula	52	Total	1900									Mork, 1942
			Leaves	1300									
			Other	600									
Finland	Betula		Total	1900									Aaltonen, 1948
Japan	Betula lat.		Leaves	1600									Ohmura and Mori, 1937
N. Carolina, USA	Betula lutea	50	Boles & Branch	440	.06	.3	2.2			1.1			Weaver, 1972
			Twigs & Bark	415	.23	1.1	2.7			.6			
			Reproductive	213	.18	.6	.8			.5			
			Decid. Fol.	2883	2.96	12.8	35.7			16.4			
			Everg. Fol.	523	.52	1.8	3.2			1.6			

Table 7 Litterfall Biomass & Nutrients

Location	Dom. Veg.	Age	Component	Biomass	kg/ha/yr				Other	Reference
					N	P	K	Ca	Mg	
N. Carolina, USA	<i>Betula lutea</i>	100+	Boles & Branch	1070	.17	.8	5.3	2.4		Weaver, 1972
			Twigs & Bark	1096	.60	3.8	9.6	2.9		
			Reproductive	260	.49	.7	2.0	4.8		
			Decid. Fol.	3188	2.38	12.7	47.7	18.4		
			Everg. Fol.	0						
Alaska, USA	<i>Betula papyrif.</i>	50	Overstorey	2650	18.0	5.0	8.3	34.5	9.2	Van Cleave in Cole & Rapp, 1980
Holme Fen, UK	<i>Betula verruc.</i>		Total Leaves Seeds	3431 283						Ovington, 1963
Delarna, Sweden	<i>Betula pub.</i>		Leaves	1700						Sjors, 1954
Japan	Broadleaf -mixed		Foliage							Iwatsubo 1976
			-broad	2360	22.21	.75	21.55	24.29	3.16	
			-conifer	1451	7.25	.33	6.18	10.16	1.43	
			Branch & bark	281	1.47	.06	.28	1.24	.14	
			Misc.	1043	9.28	.70	6.60	5.89	1.20	
			Total	5135	40.21	1.84	34.63	41.58	5.93	
Japan	<i>Camptotheca</i>		Total	6100	65.0	11.0	80.0	75.0	53.0	Kawahara et al. 1968
S.E. England	<i>Castanea</i>		Total	3566						Anderson, 1973
			Leaf	3306						
			Twigs	257						
			Other	273						
Japan	<i>Castanea cren.</i>		Leaves	1900						Ohmasa and Mori, 1937
Hino, Japan	<i>Chamae.</i>	40	Total	2514	15.17	.73	3.56	22.29	2.72	Kawahara, 1971
			Leaf	1965	12.68	.61	3.16	20.17	2.52	
			Branch	278						
			Bark	74	2.49	.12	.40	2.12	.20	
			Other	197						
			Total	5427	33.80	1.97	10.64	46.41	6.06	
	<i>Chamae.</i>	40	Leaf	4064	29.94	1.76	7.82	42.50	5.48	
			Branch	624						
			Bark	141	3.86	.21	2.82	3.91	.58	
			Other	598						

Table 7 Litterfall Biomass & Nutrients

Location	Dom. Veg.	Age	Component	Biomass	kg/ha/yr					Reference
					N	P	K	Ca	Mg	Other
Japan	Chamae. obt.		Leaves	1800						
Nagano, Japan	Conifer		Needles							
	-subalpine		-conifer(C)	2061	9.3	1.16	2.58	19.64		
			-broad(B)	373	4.0	.22	.67	2.88		
			Branches-(C)	964	2.0	.31	.16	5.84		
			-(B)	92	.3	.04	.08	.40		
			Bark	105	.3	.03	.03	.39		
			-(C)	13	.06	.01	.01	.05		
			Reprod'tive(C)	110	.8	.13	.14	.17		
			-(B)	35	.3	.05	.10	.09		
			Bud Scales	28	.2	.02	.04	.10		
			Lichen, Moss	51	.4	.03	.06	.06		
			Sasa litter	3	.01	.00	.01	.01		
			Unid'd	290	.2	.06	.13	.77		
			Total	4252	18.8	2.17	4.18	31.36		
Japan	Crypto. jap		Leaves	3800						
Kyoto, Japan	Decid. mix		Total	3485	35.31	3.48	11.55	39.87	11.08	
			Leaves	2863	28.54	2.82	9.45	33.24	10.19	
			Branches	243						
			Flowers	195	6.77	.66	2.10	6.55	0.86	
			Other	184						
			Total	3415	44.88	3.17	10.82	33.27	8.12	
			Leaves	2844	38.2	2.73	9.53	28.27	7.51	
			Branches	314						
			Flowers	44	6.67	.43	1.29	5.00	.61	
			Other	214						
Stradbroke Is. Australia	Eucalyptus	?	Total	6426	39.5	2.1	6.0	36.4	11.2	Na 7.7
Maroondah, Victoria, Australia	Eucalyptus regnans	39	Overstory	9810	34.8	2.2	11.7	36.1	8.6	Na 8.4
	E. obliqua-	38	Understory	2330	14.7	0.8	5.4	18.1	3.0	Na 1.9
	E. dives		Overstory	6557	25.4	1.4	8.9	26.7	8.6	Na 7.6
			Understory	204	1.2	0.1	0.7	0.5	0.3	Na 0.2
Minnesota, USA	Fagus	?	Total		40	10	10	82		

Ohmura and Mori, 1937

Katagiri & Tsutsumi, 1973
-avg. 6 sitesKatagiri & Tsutsumi, 1973
-avg. 5 sites

Rogers and Westman 1977

Feller (unpublished data)

Bakuzis, 1971

Table 7 Litterfall Biomass & Nutrients

Location	Dom. Veg.	Age	Component	Biomass	kg/ha/yr					Reference
					N	P	K	Ca	Mg	Other
Sweden	Fagus	90	Leaves	3010	36.1	2.71	7.95	19.20	3.29	
			Other	1410	13.8	1.09	3.54	4.77	.79	
			Total	4420	49.9	3.80	11.5	24.0	4.08	
S.E. England	Fagus		Total	4665						
			Leaf	3857						
			Twigs	231						
			Other	577						
Japan	Fagus cren.		Leaves	2800						
Ashu, Japan	Fagus cren.		Total	4213	41.46	3.08	9.16	35.38	5.82	
			Leaf	3487	39.94	2.97	8.93	33.38	5.71	
			Branch	582	1.52	.11	.23	2.00	.11	
			Other	144						
Ugod, Hungary	Fagus sylv.	25	Total	2500						
As, Norway	Fagus sylv.	25	Total	3100						
Godollo, Hungary	Fagus sylv.	45	Total	3700						
Zurich, Switzerland	Fagus sylv.	60	Total	2800						
		120	Total	1700						
Germany	Fagus sylv.	80	Overstory	4046	54.3	4.3	17.5	17.8	1.6	
		122		5378	49.4	4.0	15.9	16.2	1.4	
				3700						
Brunlanes, Norway	Fagus sylv.	80	Total	2500						
Ugod, Hungary	Fagus sylv.	80	Total	3000						
Ugod, Hungary	Fagus sylv.	80	Total	3200						
Ugod, Hungary	Fagus sylv.	80	Total	4100						
Solling, W. Germany	Fagus sylv.	125	L		53.0	4.3	21.9	15.0	1.5	Al 0.5 Cl 0.8 Fe 1.96 Na 0.9 Mn 6.59 S 3.2

Ehwald (data Liebundgut), 1957.

Ulrich in Cole & Rapp, 1980

Bonnevie-Svendsen & Gjems, 1957.

Ulrich & Mayer, 1972

Table 7 Litterfall Biomass & Nutrients

Location	Dom. Veg.	Age	Component	Biomass	kg/ha/yr					Reference
					N	P	K	Ca	Mg	Other
Solling, W. Germany	Fagus sylv.	125	Total	2980	49.40	4.0	16.0	16.2	1.45	Ulrich et al. 1974
Sveden	Fagus sylv.	45- 130	Overstory	5690	69.0	5.0	14.4	31.7	4.3	Nihlgard 1972
Denmark	Fagus sylv.	5-200	Leaves	2600						Moller, 1945:
Germany	Fagus sylv.	21- 40	Total	3500						Danckelmann, 1887:
		41- 60	Total	4200						
		61- 80	Total	4600						
		81-100	Total	5000						
		100	Total	4500						
Bavaria, Germany	Fagus sylv.	30- 60	Total	3400						Ebermayer, 1876:
		60- 90	Total	3400						
		90	Total	3300						
Germany	Fagus sylv.	41- 60	Total	3500						Danckelmann, 1887:
		61- 80	Total	3900						
		81-100	Total	4200						
Thasandt, Germany	Fagus sylv.	50- 55	Total	4200						Ebermayer, 1876 (data of Krutzsch):
			Total	3500						Ehwald, 1957:
			Total	2500						(data of Dietrich):
			Total	3500						Ehwald, 1957: (data of Wiedemann):
S. Sweden	Fagus sylv.		Total	5700						Andersson, 1970
			Leaves	3600						
UK	Fagus sylv.		Total	5800						Mason, 1970
			Leaves	3400						
Soro, Denmark	Fraxinus acef.	12	Leaves	2400						Boysen-Jensen, 1930:
USA	Hardwoods		Leaves	4221	45.89	2.92	10.8	33.9	13.7	Brinson et al. 1980
			Woody	779	7.10	0.33	0.82	4.86	0.62	
			Twigs & branches							\$ 0.228
			Bark	96	1.04	0.04	0.09	0.96	0.09	\$ 0.0460
			Woodpecker	30	0.29	0.01	0.13	0.20	0.05	\$ 0.0241
			Reproductive	1000	12.18	1.72	8.44	3.35	1.91	0.474
			Epiphytes							
			13	0.16	0.16	0.01	0.04	0.07	0.02	\$ 0.0125
			Misc.	285	4.11	0.34	0.77	1.74	0.54	\$ 0.481
			Total	6428	72.78	5.38	21.1	45.1	17.0	\$ 7.19

Table 7 Litterfall Biomass & Nutrients

Location	Dom. Veg.	Age	Component	Biomass	kg/ha/yr					Reference
					N	P	K	Ca	Mg	
Norway (Grue)	Larix decid.	90	Total	2100						Bonnevie-Svendsen & Gjems, 1957
N. Island, N. Zealand	Larix dec.	43	Total	3530	25.8	2.4	4.3	20.8	4.0	Will, 1958
			Needles	2076						
Tennessee	Liriodendron	50	Overstorey	4290	31.3	2.8	19.0	77.7		Harris in Cole and Rapp, 1980
	Liriodendron, Carya, Quercus	30-80		4330	16.2	2.7	19.1	8.3		
S. Carolina, USA	Mix	1-60	Total	5153						Metz, 1952
			Leaves	3657	20.99			40.04	9.25	
			Branches	1489						
	Mix	1-40	Total	4434						
			Leaves	3402	26.27			45.87	9.71	
			Branches	1032						
	Mix	1-60	Total	5727						
			Leaves	4101	28.49			33.79	12.03	
			Branches	1626						
	Mix, decid.	1-45	Total	4834						
			Leaves	3963	24.70			94.81	22.35	Metz, 1952
			Branches	870						
	Mix, decid.	1-150	Total	5108						
			Leaves	4398	29.48			109.73	24.20	
			Branches	710						
	Mix, decid.	1-50	Total	4536						
			Leaves	3917	31.19			80.88	17.04	
			Branches	618						
Japan	Mix broad		Litterfall	4800	78.5	6.21	26.4	136	16.9	Katagiri & Tsutsumi, 1978
	Lower slope		Branchfall	2110	8.7	.69	2.5	23.7	1.2	
	Mix broad		Litterfall	3190	32.2	1.65	8.6	52.5	6.3	
	Upper slope		Branchfall	900	3.6	.17	.9	8.0	.5	
Japan	Mix broad, upper slope		Leaves	2444	19.9	2.1	8.4	23.9	8.0	Katagiri & Tsutsumi, 1973
			Branches	189						
			Flowers	298						
			Others	173						
			Total	3104	25.4	2.7	11.1	29.6	8.7	
	mid slope		Leaves	2884	23.4	2.6	7.8	30.9	9.9	
			Branches	228						
			Flowers	165						
			Other	131						
			Total	3408	28.1	3.0	8.8	35.5	10.4	
	lower slope		Leaves	2796	37.8	3.3	11.1	40.0	11.6	
			Branches	289						
			Flowers	354						
			Other	246						
			Total	3685	51.0	4.6	15.2	51.2	13.2	

Table 7 Litterfall Biomass & Nutrients

Location	Dom. Veg.	Age	Component	Biomass	kg/ha/yr					Reference
					N	P	K	Ca	Mg	
Japan	Mix broad, lower slope		Litter	3250	43.9	3.2	13.4	53.6	9.1	Katagiri & Tsutsumi, 1976
			Lge branches	1280	6.6	.4	1.8	16.0	1.1	
			Litter	3480	35.3	1.9	10.2	52.7	7.4	
			Lge branches	1540	7.0	.4	2.2	7.5	1.1	
Minamata, Japan	Mix, broad		Total	7523	72.48	2.79	16.35	72.63	13.81	Kawahara, 1971
			Leaf	3991	49.11	2.04	15.15	33.91	9.07	
			Branch	3165						
			Bark+other	366	23.37	.75	3.20	38.72	4.74	
Lund, Sweden	Mix, decid.		Leaves	2800						Lindquist, 1938
N. Carolina, USA	Mix, decid.		Total	4250	33.25	4.93	17.98	43.64	6.54	Cromack, 1973
			Leaves	2773	23.57	3.48	13.00	34.11	6.10	
			Stems	893	4.62	.77	.68	6.45	.10	
			Other	582		.70				
Belgium	Mixed decid.	80	Overstory		50.0	2.4	21.0	110.0	5.6	Duvigneud-Denaeyer in Cole & Rapp, 1980
New Zealand	Nothofagus		Leaves	4142	27.84	1.89	6.78	41.06	7.63	Miller, 1963
			Twigs	1652	6.65	.39	.74	25.49	2.49	
			Total	5772						
Craigieburn, N. Zealand	Nothofagus sol.		Total	3700						Wardle, 1970
Wairarapa, N. Zealand	Nothofagus sol.		Total	3100						Bagnall, 1972
			Total	5700						
Solling, W. Germany	Picea abies	125	(-branches)	3390	40.7	3.6	7.6	14.0	1.29	Ulrich et al. 1974
Moscow, USSR	Picea abies	45-68	Total	6200						Ehwald, 1957
			Total	6900						
Thasant, Germany	Picea abies		Total	3800						Ehwald, 1957 (data of Zimmerle)
Nordbo, Denmark	Picea abies		Leaves	1600						Bornebusch, 1937

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Table 7 Litterfall Biomass & Nutrients

Location	Dom. Veg.	Age	Component	Biomass	kg/ha/yr				Ca	Mg	Other	Reference
					N	P	K					
Grue, Norway	Picea abies	80	Total	2000								Krutzsch, 1986
Germany	Picea abies	21- 40	Total	3100								Danckelmann, 1987
		41- 60	Total	3700								
		61- 80	Total	3800								
		81-100	Total	3600								
Ringsaker, Norway	Picea abies	30-40	Total	2000								Krutzsch, 1986
Brunlanes, Norway	Picea abies	45- 65	Total	4500								Krutzsch, 1986
Finland	Picea abies		Total	1600								Aaltonen (from Svinnuhood), 1948
Bavaria, Germany	Picea abies	30	Total	4500								Ebermayer, 1876
		30-60	Total	3400								
		60-90	Total	2900								
		90	Total	2800								
Velikie Luki, Picea abies, Betula		38-90	Total	2000								
			Leaves	1500								
			Other	500								
			Total	2700								
Alaska, USA	Picea mariana	51	overstory		1.1	1.4	.03	.11	.09			Van Cleave in Cole & Rapp, 1980
		55			1.6	.12	.26	4.0	.17			
		130			3.6	.4	.7	4.1	.3			
New York, USA	Picea rubens	150	Leaves	1900	16.0	1.8	6.2	14.1	3.5			Chandler, 1944
N. Wales, UK	Picea sit.	30	Foliage	2100	24.4	5.19	5.87	8.24				Owen, 1954
Vologda, USSR	Picea uliginosa	100-	Needles	555	4.22	.61	1.83	10.65	.55			P'yavchenko, 1960
		150	Leaves	930	8.93	.96	1.02	21.48	3.81			
			Woody	1140	2.74	.51	1.25	2.96	.68			
			Total	4638	35.10	5.74	19.67	62.22	12.67			
		70-	Needles	552	1.99	.30	.94	5.52	1.10			
		200	Woody	406	.61	.29	.57	.69	.26			
			Total	1158	3.41	.73	1.82	8.09	1.48			

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Table 7 Litterfall Biomass & Nutrients

Location	Dom. Veg.	Age	Component	Biomass	kg/ha/yr			Ca	Mg	Other	Reference
					N	P	K				
New Mexico, USA	Picea, Abies	300	Total	1106	5.6						Vitousek et al. 1982
N. Carolina, USA	Picea, Abies	50	Boles & Branches Twigs & Bark Reproductive Decid. Fol. Everg. Fol.	510 1033 1071 285 3115	.09 .53 1.17 .33 2.55	.3 2.3 3.6 1.0 8.5	2.5 4.1 2.6 3.0 17.5	1.7 1.6 1.7 1.4 7.1			Weaver, 1972
Minnesota, USA	Pinus	?	Total	35	4	5	19				Bakuzis, 1971
Cloquet, Minn. USA	Pinus	50	Leaf litter Ash	2151 55.8	14.7	2.7	2.9	18.0			Alway & Zon, 1930
Australia	Pinus	37	Total	3500							Bohmerle, 1906
Czechoslovakia	Pinus	94	Total Leaves Other	3600 2200 1400							Perina & Vitrova, 1958
Cloquet, Minn. USA	Pinus	100	Leaf litter Ash	2446 51.3	10.4	2.4	3.5	15.5			Alway & Zon, 1930
Cass Lake, Minn. USA	Pinus	250	Leaf litter Ash	2137 73.4	15.8	3.2	3.7	22.5			Alway & Zon, 1930
S. Carolina, USA	Pinus	20-25 30-40 10	Total Leaves Branches Total Leaves Branches Total Leaves Branches	6023 4798 1225 4398 3149 1249 4351 4042 309							Metz, 1952
Ontario, Canada	Pinus banks.	30	Trees Herb	3729 331	20.52 4.67	1.20 .40	4.88 2.19	13.31 1.66	1.73 .40		Foster, 1974
Aomori, Japan	Pinus dens		Total Total Total Total	3262 3902 4434 3860	15.58 18.22 26.37 18.65	1.68 1.76 1.80 1.86	3.97 4.29 6.87 5.51	19.98 24.81 29.26 29.57	2.82 5.51 1.79 2.86		Satoo, 1970
			Total	4493	26.57	1.76	7.31	34.16	1.99		

Table 7 Litterfall Biomass & Nutrients

Location	Dom. Veg.	Age	Component	kg/ha/yr					Reference
				Biomass	N	P	K	Ca	
North Island, N. Zealand	Pinus rad.	4-6	Total	4237	34.0	3.3	13.2	27.7	5.1
			Needles	3334	39.0	4.6	14.1	28.6	6.0
		26	Total	5982	37.0	4.5	14.5	20.3	5.0
			Needles	4064	34.7	3.2	17.1	48.9	7.2
		43	Needles	4925					
Victoria, Australia	Pinus radiata	15	Aboveground control	3475	22	1.6	8.6	20	5.9
			Irrigated waste water	3970	25	2.3	11.2	23	6.1
		Fertilized	Fertilized	3500	22	2.1	8.6	19	5.6
			Irrigated + fertilized	3970	26	2.7	10.9	22	6.0
		24	Leaves	3800	24.9	2.6	12.6	20.6	6.7
New York, USA	Pinus resinosa	24	Leaves	3800	24.9	2.6	12.6	20.6	6.7
New England, USA	Pinus resinosa	55	Total	7260	40				
Conn., USA	Pinus resinosa Pinus strobus	30-50	Total	4000					
			Total	4000					
			Needles	3245	26.50	3.70	5.50	19.20	2.70
			Stems	3184	26.27	3.66	5.32	19.08	2.70
			Other	34	.14	.03	.10	.10	.00
N. Carolina, USA	Pinus strobus	16	Other	27	.10	.02	.10	.00	.00
			Leaves	3100	29.1	2.0	5.2	17.6	6.1
			Leaves	2900	33.4	1.5	5.2	17.6	4.7
			Overstory	4369	33.9		18.1	44.5	
New York, USA	Pinus strobus	24 65	Leaves	3100	29.1	2.0	5.2	17.6	6.1
			Leaves	2900	33.4	1.5	5.2	17.6	4.7
N. Carolina, USA	Pinus strobus	60- 200	Overstory	4369	33.9		18.1	44.5	
Minn., USA	Pinus strobus		Total	2955	15.6	2.0	2.6	27.3	4.4
			Leaves	188	1.8	.2	1.0	.7	.3
Conn., USA	Pinus strobus		Cones						
			Total	1700					

Cromer et al. 1984

Chandler, 1943

Vitousek et al. 1982

Lunt, 1951

Cromack, 1973

Chandler, 1943

Swank in Cole
& Rapp, 1980

Ovington, 1963

Ehwald, 1957
(data of Abramova)

Table 7 Litterfall Biomass & Nutrients

Location	Dom. Veg.	Age	Component	Biomass	kg/ha/yr			Ca	Mg	Other	Reference
					N	P	K				
Central Sweden	Pinus sylv.	120-150	Needles	330	3.8	0.25	0.71	3.30	0.35	Na 0.07 S 0.41	Bringmark, 1977
			Cones	25	0.1	0.01	0.03	0.01	0.01	Na 0.00 S 0.01	
			Twigs	106	0.5	0.02	0.03	0.16	0.01	Na 0.00 S 0.05	
			Other	290	0.9	0.01	0.27	1.02	0.12	Na 0.01 S 0.06	
Evo, Finland	Pinus sylv.	88	Total	1800							Viro, 1955
			Leaves	1200							
			Other	600							
Viipputa, Finland	Pinus sylv.	58	Total	2700							Viro, 1955
			Leaves	1600							
			Others	1100							
Bavaria, Germany	Pinus sylv.	25-50 50-75 75-100 80 100 120	Total	2900							Ebermayer, 1876
			Total	3000							
			Total	3600							
			Total	4000							
			Total	3800							
			Total	3600							
			Total	3600							
Brjanek, USSR	Pinus sylv. & herb		Total	3200							Ehwald, 1957 (data of Sacharov)
			Leaves	2700							
			Other	500							
			Total	6900							
			Leaves	4700							
Voronezh, USSR	Pinus sylv.	20 40 60 80 100	Other	2200							Rodin and Basilevich 1967
			Leaves	2500							
			Leaves	2300							
			Leaves	1900							
			Leaves	2000							
Marschallersruhe Germany	Pinus sylv.	45	Leaves	1300							Viro, 1955
			Total	3900							
			Total	3900							
Evo, Finland	Pinus sylv.	50	Total	2300							Viro, 1955
			Leaves	1700							
			Other	600							

Table 7 Litterfall Biomass & Nutrients

Location	Dow. Veg.	Age	Component	Biomass	kg/ha/yr					Reference
					N	P	K	Ca	Mg	
Bavaria, Germany	Pinus sylv.	21-40	Total	3300						Danckelmann, 1987
		41-60	Total	3200						
		61-80	Total	3200						
		81-100	Total	3100						
		100	Total	3000						
		21-40	Total	2400						
Kiev, USSR	Pinus sylv.	41-60	Total	2300						Ehwald, 1957
		61-80	Total	2200						
		81-100	Total	2000						
		100	Total	1900						
Finland	Pinus sylv.	10,45,10s	Total	2400						Aaltonen (from Svinuhood), 1948
		Total	Total	2600						
Thasent, Germany	Pinus sylv.	Total	Total	2000						Ehwald, 1957
		Total	Total	1000						
		Total	Total	3000						
Eberswalde, Germany	Pinus sylv.	Total	Total	3600						Lespeyres, 1898
		Total	Total	3600						
Cheshire, UK	Pinus sylv.	Total	Total	4800						Kendrick, 1959
		Leaves	Leaves	4100						
		Other	Other	700						
Spieess, Germany	Pinus sylv.	54	Total	3600						Sonn, 1960
		Total	Total	3600						
USSR	Pinus sylv., Quercus Pinus sylv., Acer	Total	Total	1300						Ehwald, 1957 (data of Nesterou)
		Total	Total	2000						
		Total	Total	4500						
		Total	Total	3000						
Moscow, USSR	Pinus sylv., Acer Pinus sylv., Acer Pinus sylv. & mix	30	Total	3600						Ehwald, 1957 (data of Nesterou)
		Total	Total	3600						
		Total	Total	4200						
		Total	Total	4200						

Table 7 Litterfall Biomass & Nutrients

Location	Dom. Veg.	Age	Component	Biomass	kg/ha/yr					Other	Reference
					N	P	K	Ca	Mg		
N. Carolina, USA	Pinus taeda	11	Needles	6200	35.0	6.5	12.2	22.7	5.6		Jorgensen et al. 1980
			Branches	774	2.7	0.2	0.6	2.1	0.1		
			Leaves	9	0.1	0.1	0.1	0.1	0.1		
			Fine material	508	13.8	0.8	0.8	0.9	0.3		
		32	Needles	4390	23.8	3.9	9.6	15.1	3.8		Wells & Jorgensen, 1975
			Branches	800	2.3	0.2	1.0	2.1	2.0		
			Leaves	60	0.5	0.1	+0.2	0.8	0.2		
			Fine material	285	7.3	0.8	0.8	0.6	0.4		
N.S. Carolina, USA	Pinus taeda	11-15 16-17 24-27 28-29 31-39	Total	7749	53.24	7.54	13.90	26.17	6.20		Wells et al. 1975
				3374	25.84	3.59	7.00	10.44	3.14		
				5129	33.68	3.56	9.15	16.60	4.07		
				2213	15.60	1.90	3.87	8.13	2.08		
N. Carolina, USA	Pinus taeda	14		6033	36.91	5.17	12.19	19.61	4.75		Wells et al. 1975
			Needles	4750	26.8	3.05	4.92	4.75	3.52		
			Branches	572	1.7	.10	.15	1.31	.11		
			Other	240	1.9	.15	.23	.50	.11		
Shiga, Japan	Pinus, Chamaecyparis		Needles	5136	30.7	3.19	5.46	6.38	3.28		Kawahara 1971
			Branches	1118	4.0	.26	.41	2.16	2.06		
			Other	372	2.8	.21	.38	.78	.16		
			Total	5235	26.1	1.13	8.39	40.47	2.97		
Kyoto, Japan	Pinus, Quercus		Total	7756	28.8	2.50	9.09	25.00	4.85		Daniel, 1975
			Total	4508	49.3	4.93	12.32	46.29	6.23		
Wellington, N. Zealand	Podocarpus + Metrosideros		Total	6865							Sviridova, 1960
			Leaves	3229							
			Fruit+seeds	579							
			Insects	8							
Lunadacs, Hungary	Populus	24	Twigs <28cm	1056							Sviridova, 1960
			Twigs >28cm	1992							
			Total	4400							
Vosonegh, USSR	Populus	30	Total	6000							Sviridova, 1960
			Total	5200							
			Total	5400							
			Total	4600							

Table 7 Litterfall Biomass & Nutrients

Location	Dom. Veg.	Age	Component	Biomass	kg/ha/yr			Ca	Mg	Other	Reference
					N	P	K				
Minnesota, USA	Populus	49	Total	3675	33	6.7	19	60	8.0		Perala and Alban 1979
	Picea	41	Total	5253	41	5.1	12	60	4.1		
	Pinus res.	41	Total	5468	34	3.1	13	24	5.3		
	Pinus banks.	41	Total	5322	41	3.9	11	28	5.0		
Erd, Hungary	Populus alba	30	Total	4600							Rodin & Basilevich 1967
Erd, Hungary	Populus alba	15-20	Total	3500							Rodin & Basilevich 1967
Godollo, Hungary	Populus nigra	35	Total	4000							Rodin & Basilevich, 1967
New Mexico, USA	Populus trem.	60	Total	2530	15						Vitousek et al. 1982
USSR	Populus trem.	10	Total	3850							Rodin & Bazilevich, 1967
	Leaves			3750	93	9	53	63	10	1	
	Other			100							
	Total	25		4110							
	Leaves			3620	90	9	51	61	9	1	
	Other			490							
	Total	50		4880							
	Leaves			4470							
Voronezh, USSR	Populus trem.	10	Total	3900							Remezov & Bykova, 1953
	Total	25		4100							
	Total	50		4900							
USA	Populus trem.	10	Total	1320							Van Cleve & Noonan, 1975
	Leaves			1100	9.0	2.0	5.2	23.9	3.7	.6	
	Twigs			210						.2	
	Other			7						.1	
	Total	50		2190							
	Leaves			1780	19.7	4.4	8.8	42.6	6.3	.7	
	Twigs			320						.7	
	Other			89						.2	
	Total			2220							
	Leaves			1620	13.5	2.7	4.7	28.1	5.3	.6	
	Twigs			440						.4	
	Other			160						.2	

Table 7 Litterfall Biomass & Nutrients

Location	Dom. Veg.	Age	Component	Biomass	kg/ha/yr			Ca	Mg	Other	Reference
					N	P	K				
Boone City, Missouri, USA	Quercus		Leaves	3726							Rochow, 1975
			Woody	860							
			Leaves	3652							
			Woody	1170							
			Leaves	6107							
			Woody	644							
			Leaves	3620							
			Woody	896							
			Leaves	1876							
			Woody	1344							
			Leaves	3951							
			Woody	783							
			Leaves	3565							
			Woody	762							
			Leaves	5026							
			Woody	288							
Georgia, USA	Quercus alba Pinus taeda	34	Leaves	4800	36.5	2.7	19.8	49.1	8.7		Monthly mean for 8 monthsx12 Harris in Cole & Rapp, 1980
			Woody	4450	34.1	2.4	16.4	45.0	7.5		
			Total	6200							
Tennessee, USA	Quercus alba Quercus prinus	30-80 30-80	Leaves	4600							Hole & Nielsen
			Woody	1500							
			Total	6100							
Washington, USA	Quercus alba	100-125	Leaves	2608	23.0	1.0	9.0	47.0	3.0		Rapp, 1969
			Woody	1584							
			Total	4192							
Grabels, France	Quercus cocc.		Leaves	2278	19.0	1.0	9.0	33.0	2.0		Rapp, 1969
			Woody	1405							
			Total	3683							
St. Piy du Fesc, France	Quercus cocc.		Leaves	243							Rodin & Basilevich, 1967
			Woody	626							
			Total	869							
Pestsag, Hungary	Quercus cerris	35	Leaves	3300							
			Woody								
			Total								

Table 7 Litterfall Biomass & Nutrients

Location	Dom. Veg.	Age	Component	Biomass	kg/ha/yr				Ca	Mg	Other	Reference
					N	P	K					
Godollo, Hungary	Quercus cerris	45	Total	3800								
Ugod, Hungary	Quercus cerris	70	Total	2700								Rodin & Basilevich, 1967
Kallo, Hungary	Quercus cerris	83	Total	3400								Rodin & Basilevich, 1967
France	Quercus ilex	150	Overstory	3840	32.8	2.8	16.2	63.9	4.6			Rodin & Basilevich, 1967
Rouquet, France	Quercus ilex	130-150	Total	3842	33.0	3.	16.0	64.0	4.0			Loissant & Rapp in Cole & Rapp, 1980
			Leaves	2446								Rapp, 1969
			Wood	800								
			Other	596								
Madelaire, France	Quercus ilex		Total	6998	87.0	10.0	38.0	122.0	10.0			Rapp, 1969
			Leaves	2723								
			Wood	1496								
			Other	2779								
California, USA	Quercus lull. Pinus ponder. Mix. decid	50-100 150 50	Total	1								
			Total	2100								
			Total	4500								
Belgium	Quercus mixed	115-160	Overstory	5600	59.0	3.4	28.0	66.0	9.7			Duvigneud-Denaeyer in Cole & Rapp, 1980
Ashu, Japan	Quercus mong.		Total	4508	49.32	4.95	12.32	46.29	6.23			
			Leaf	3719	45.02	4.32	9.80	40.09	5.43			
			Branch	361	4.30	.63	2.52	6.20	.80			
			Other	428								
U.K.	Quercus pet.		Leaves	21.05	.92	.63		16.80	2.74			Carlisle et al. 1966
			Twigs	7.73	.39	1.6		4.18	.53			
			Male fl.	4.31	.31	1.2		.68	.24			
			Buds	3.08	.20	.5		1.08	.15			
			Acorns	.44	.03	.2		.23	.04			
UK	Quercus pet.		Total	3900								Carlisle et al. 1966
			Leaves	2100								

Table 7 Litterfall Biomass & Nutrients

Location	Dom. Veg.	Age	Component	Biomass	kg/ha/yr				Ca	Mg	Other	Reference
					N	P	K					
Varner Wood, UK	Quercus petr.		Total Leaves Flowers	3127 31								Rodin & Basilevich 1967
Kunadacs Hungary	Quercus robur	51	Total	4000								Rodin & Basilevich, 1967
Kalio, Hungary	Quercus robur	60	Total	4400								Rodin & Basilevich, 1967
Matra, Hungary	Quercus robur	70	Total	4700								Rodin & Basilevich 1967
Japan	Quercus serr.		Leaves	2300								Ohmasa and Mori, 1937
Laos, Hungary	Quercus sessil	75	Total	4600								
Illinois	Quercus-Carya -Liriodendron	70 -100	Total	5688			25.8		99.5	12.6		Pearson, 1978
Illinois	Quercus-Carya	150	Total Xeric Mesic	6200 7100	57	4	41		111	8		Rolfe et al. 1978
Japan	Quercus, mixed moist soil		Leaf Branch Other Total	3260 1340 530 5130	50.80 6.97 8.85 66.62	1.66 .27 .61 2.54	9.78 1.02 .80 11.60		30.86 12.54 4.49 47.89	5.41 1.69 .83 7.93		Katagiri et al. 1978
New England, USA	Quercus, Acer	50	Total	4890	41							Vitousek et al. 1982
UK	Quercus, Betula	80	Overstory	3700	63.5	2.6	19.0		83.3	9.7		Satchell in Cole & Rapp, 1980
Arnhem, Netherlands	Quercus, Betula		Total Leaves Other Total	3700 2700 1000 4100								Witkamp & Van der Drift, 1961
	Betula, Quercus		Total Leaves Other	2500 1600								

Table 7 Litterfall Biomass & Nutrients

Location	Dom. Veg.	Age	Component	Biomass	kg/ha/yr				Ca	Mg	Other	Reference
					N	P	K					
Japan	Quercus, mix -dry soil		Leaf	4000	40.72	1.70	9.67	47.44	5.31			Katagiri et al., 1978
			Branch	900	7.30	.19	.89	11.35	.74			
			Other	560	10.11	.52	1.39	4.29	.78			
			Total	5460	58.13	2.41	11.95	63.08	6.83			
Oregon, USA	Thuja plic. Pseud. menz. Ab. amab. Acer macro. Pseud. menz. Pinus Alnus rub. Tsuga het. Picea sit. Pinus pond. Pinus pond. Pinus cont.	350	Total	2052	12.7	1.8	7.3	45.9	.9			Tarrant et al., 1951
				1897	16.3	2.9	2.9	17.8	.5			
				1696	21.2	2.0	4.1	15.5	1.0			
				1414	16.2	1.7	16.0	22.9	.2			
				881	7.5	.8	1.8	8.6	.2			
				1292	9.9	1.5	3.9	8.0	1.1			
			Total	1256	29.6	1.6	12.4	10.3	.1			
				1003	7.7	1.1	1.9	6.0	.6			
				862	10.0	.9	2.0	4.2	.8			
				770	6.0	.8	1.8	8.6	.6			
Japan	Thujopsis dol. Lapix kaem. Abies sach. Pic. jeg. Pic. gleh.		Leaves	3900								Ohmura and Mori, 1937
			Leaves	2000								
			Leaves	1100								
			Leaves	1500								
New York, USA	Tilia am. & mix	30-70	Leaves	2900	21.6	3.1	14.6	83.6	12.1			Chandler, 1941
New York, USA	Tilia am. & mix	30-70	Leaves	3100	17.6	4.7	21.4	78.2	10.0			Chandler, 1941
Godollo, Hungary	Tilia cord.	45	Total	3600								Rodin & Basilevich 1967
Kochi, Japan	Tsuga		Total	5236	36.4	1.81	10.12	32.60	5.33			Ando et al., 1977
New York, USA	Tsuga cana.	150	Leaves	1500	14.5	1.0	3.8	9.5	1.9			Chandler, 1943
Oregon, USA	Tsuga mert.		Total	5949	23.39	3.85	5.01	50.76	3.08			Abee, 1973
			Needles	2247	11.48	2.59	3.07	33.35	1.58			
			Reprod. Woody	871 2124	3.92 .	.51 .	.66 .	2.62 .	.46 .			

Table 7 Litterfall Biomass & Nutrients

Location	Dom. Veg.	Age	Component	Biomass	kg/ha/yr				Ca	Mg	Other	Reference
					N	P	K					
Oregon, USA	Tsuga mert.		Total	6390	35.23	5.60	10.08	56.36	4.22			Abee, 1973
			Needles	2953	16.55	3.82	5.98	36.95	2.68			
			Reprod.	1281	7.06	.69	1.43	2.06	.70			
			Woody	1138								
Oregon, USA	Tsuga mert.		Total	5143	23.30	5.15	7.21	50.50	3.52			Abee, 1973
			Needles	3204	14.67	4.18	5.28	38.11	2.43			
			Reprod.	742	2.40	.36	.62	1.13	.45			
			Woody	811								
Oregon, USA	Tsuga mert.		Total	4798	34.12	5.60	7.56	119.91	3.40			Chandler, 1943
			Needles	2538	12.41	2.48	3.61	33.24	1.90			
			Reprod.	545	2.18	.23	.49	1.10	.26			
			Woody	817								
			Total	7060	35.53	5.38	10.32	41.30	4.53			
			Needles	3727	22.26	4.01	7.92	28.51	3.07			
			Reprod.	528	3.12	.35	.60	.69	.29			
			Leaves	2300	13.0	0.9	5.4	46.4	3.2			
New York, USA	Tsuga occid.	65										
Japan	Tsuga sieboldii	120-443										Ando in Cole & Rapp, 1980
			Overstorey	4686	20.2	1.5	6.8	24.8	3.6			
Washington, USA	Tsuga, Picea	120	Total	6200	44							Vitousek et al., 1982
Erd, Hungary	Ulmus	40	Total	4900								Rodin & Basilevich, 1967
			Leaves	1400								
Japan	Zelk. serrata											Ohmura and Mori, 1937

¹From Bray & Gorham, 1964, or Rodin and Basilevich, 1967.

Table 8 Defoliation

Location	Dom. Veg.	Age	Component	Biomass	N	P	K	Ca	Mg	Other	Reference
North Carolina, Mixed hardwoods USA			Insect bodies	1-3			0.01-	0.002-	0.001-		Schowalter et al. 1981
			Fra	200-			0.05	0.01	0.01		
			Fra	1000			3-20	0.4	0.4-1		
Scotland	Pinus nigra	40	Bird droppings		.01-6						Miller, Cooper & Miller 1976
USSR	Quercus	33	Fra	330	10.7	.7	10.6	6.2	2.6		Rafes, 1971
			Bodies	15	1.4	.2	.4	.1	0.0		
	Quercus	59	Fra	230	7.5	.5	7.4	4.3			
			Bodies	10	1.0	.2	.3	0.0			
		74	Fra	350	11.4	.7	11.2	6.5	2.7		
			Bodies	17	1.6	.3	.5	.1	0.0		
England	Quercus	228	Fra	750	24.4	1.5	24.1	14.0	5.7		Carlisle et al. 1966
			Bodies	35	3.4	.5	1.1	.1	.1		
		40-120		0-570	0-6.5	0-.81	0-3.5	0-1.6	0-.39	Na 0-.13	
Japan	Tuga, Betula		Insect bodies	2.45	.1	.01	.02	.01			Shidei & Kira 1977
			Feces & dust	122.27	.56	.08	.15	.07			

Table 9 Throughfall & Stemflow

Location	Dom. Veg.	Age	T/S ¹	C	N	Input kg/ha/yr			Ca	Mg	Na	Reference
						P	K					
Japan	"Hinoki"	T			6.3	.12	13.1		16.6	4.2		Iwatsubo & Tsutsumi, 1967
		S			.7	.02	1.6		1.7	.4		
		T			5.70	.42	39.1		13.1	3.7		
		S			1.7	.06	9.3		4.6	1.1		
Washington, USA	Abies amabilis	T			2.6	0.5	12.3		6.0	2.2		Turner & Singer, 1976 ¹
Washington, USA	Abies grandis	T				0.89	0.32		3.77	2.51	0.26	Tiedemann et al., 1980 ¹
New Brunswick,	Acer rubrum	55 S		1.78	.16		2.22		.32	.08	.13	Mahendrappe, 1974
N. Hampshire, USA	Acer, Betula, Fagus	110 T		Org. Mat. 104	4.7	.6	26.1		5.0	1.5		Whittaker in Cole & Rapp, 1980
		S		11.5	.5	.1	3.4		.4	.1		
Oregon, USA	Alnus	T			6.30							Tarrant et al., 1968
		S			.02							
Washington, USA	Alnus rubra	T&S			10.6	1.3	15.0		12.4	5.58		Turner et al., 1976 ¹
Washington,	Alnus rubra	30 T			8.8	1.0	12.2		10.0	5.0		Turner, 1975
		S			.1		.4		.2	.08		
Cedar Falls, Wash. USA	Alnus rubra	T			2.80	.08	13.02		5.76	2.96		Rahman, 1964
	Alnus rubra	S			.24	.01	.95		.40	.12		
S. Norway	Betula	T				0.2	6.2		3.0	1.5	7.8	Hornqvist and Joranger, 1974 ¹
										Cl 13.8	5.7	
Russia	Betula	T							8.2	1.6		Sokolov, 1972 ¹
										Cl 1.5		
										SO4-S 1.0		
										NH4-N 2.4		
										NO4-N 0.2		
N. Carolina USA	Betula lutea	50 T					16.9		5.3	2.7		Weaver, 1972
		100+ S					1.0		.5	1.7		
New Brunswick, Canada	Betula papyrif.	61 S		.76	.04		.11		.08	.02	.09	Mahendrappe, 1974
Alaska, USA	Betula papyrif.	50 T		Org. Mat. 30.33								Van Cleave in Cole & Rapp, 1980
		S		3.42	2.1	.20	1.46		1.01	.55		
					.1	.006	.11		.03	.01		

Table 8 Throughfall & Stemflow

Location	Dom. Veg.	Age	T/S ¹	C	N	Input kg/ha/yr	P	K	Ca	Mg	Na	Reference
Japan	Broadleaf -upper slope -lower slope	T T			6.3 4.3	.91 .32	39.3 20.2		23.3 8.8	8.9 4.3		Katagiri & Tsutsumi, 1978
Kyoto, Japan	Broadleaf	T			6.15	.19	28.94		13.05	4.63		Tsutsumi, 1978
	Broadleaf	S			3.26	.06	6.25		5.16	1.66		
	Broadleaf	T			5.70	.42	39.12		13.07	3.70		
	Chamaecyparis	S			1.62	.06	9.31		4.57	1.14		
	Chamaecyparis	T			7.37	.03	11.82		16.21	3.09		
	Chamaecyparis	S			1.09	.01	1.38		1.79	.44		
	Chamaecyparis	T			6.27	.12	13.13		16.64	4.24		
	Chamaecyparis	S			.68	.02	1.57		1.71	.38		
Japan	Broadleaf	T&S			8.5	.22	32.6		15.8	6.1		Iwatsubo & Tsutsumi, 1967
Japan	Campotheca	Young T			4.9	1.5	27.5		25.3	10.0		Tsutsumi, 1977
	Chamaecyparis	Mature										
	Pinus	T			4.44	1.08	20.99		25.56	5.77		
Kyoto, Japan	Campotheca	T&S			5.3	1.5	27.5		25.3	10.4		Iwatsubo, 1976
S. Norway	Conifer						83.8		32.6	11.2	41.2	Haughbotn, 1973 ²
							30.8		17.1	6.2	10.9	S04-S
										504-S	21.1	S04-S
S. Norway	Conifers near factory	T					42.0		48.1	10.1	39.1	Haughbotn, 1973 ²
										S04-S	111.2	
S. Georgia	Cypress swamp	T				0.96	6.55		6.24	2.59		Schlesinger, 1978 ²
										N03-N	2.68	
Coastal California, USA	E. globus	T				0.27	11.39		8.52	4.22	15.32	McColl & Bush, 1978 ²
										NH4-N	1.81	
										N03-N	0.50	
Mariondale, Victoria, Australia	E. regnans	38 T			0.4	0.1	30.8		13.4	5.9	11.5	Feller, unpublished data
	E. obliqua-	S			0.2	0.0	5.9		3.0	1.9	3.4	
	E. dives	38 T			-	0.0	14.9		5.5	6.7	8.8	
		S			0.0	0.0	0.2		0.1	0.1	0.3	
New Zealand	Eucalyptus	T					13.38		8.01	7.29	25.43	Attwill, 1966 ²
W. Australia	Eucalyptus	T&S				0.52	22.8		9.8	8.9	6.6	Prebble & Stirk, 1980 ²

Table 9 Throughfall & Stemflow

Location	Dom. Veg.	Age	T/S ¹	C	N	Input kg/ha/yr			Ca	Mg	Na	Reference
						P	K					
Illinois, USA	Mixed hardwoods	T&S				0.28	4.02		7.92	0.37 NO ₃ -N	0.11	Weaver & Brown, 1979 ²
New Hampshire, USA	Northern hardwoods	T&S			11.71	0.73	30.45		7.62	2.17 Cl S04-S H ₂ O	0.66 26.06 26.05 478	Eaton et al., 1973 ³
New Zealand	Nothofagus	T			2.69	0.56	31.05		13.45	13.45 Cl Cl	73.98 160.29 10.42	Miller, 1963 ⁴
Russia	Picea abies	T							10.9	2.3 Cl S04-S NH ₄ -N NO ₃ -N	1.9 2.0 3.2 0.2	Sokolov, 1972 ⁵
S. Norway	Picea abies	T				0.1	7.4		3.9	1.6 Cl S04-S	9.8 19.5 8.6	Hornbvedt and Joranger, 1974 ⁶
S. Sweden	Picea abies	55 T S			21.5 2.6	430 71	22.6 4.5		14.7 2.7	5.25 .90	22.6 3.6	Nihlgard, 1970
USSR	Picea abies	45 T&S			1.6	.3	1.9		2.5			Kazimirov, 1973
Germany	Picea abies	34 T&S 87 T&S 115 T&S			3.7 3.7 3.7	.2 .2 .2	23.6		19.0	.2		Ulrich in Cole & Repp, 1980
Sweden	Picea abies	60 T&S			16.0	.4	25.2		13.9	5.2		Nihlgard, 1972
Minnesota, USA	Picea mariana	T&S			7.16	0.62	4.04		5.27	1.31 NH ₄ -N NO ₃ -N	1.18 1.67 1.67	Verry & Timmons, 1977 ⁷
Alaska, USA	Picea mariana	51 T 55 T 130 T			.8 .8 .8	.1 .09 .09	.83 .83 .83		1.14 1.1 1.14	.14 .14 .14		Van Cleave in Cole & Repp, 1980
New Brunswick, Canada	Picea rubens Picea glauca Pinus resinosa Pinus strobus Larix Abies balsamea	46 S 32 S 42 S 40 S 52 S 49 S			1.48 5.61 .64 1.55 3.44 7.90	.10 .29 .03 .09 .09 .21	.41 4.53 .16 .94 1.05 2.43		.25 .61 .14 .15 .38 .45	.04 .18 .02 .05 .12 .13	.07 .28 .11 .13 .17 .20	Mehendrappe, 1974

Table 9 Throughfall & Stemflow

Location	Dom. Veg.	Age	T/S ¹	C	N	Input kg/ha/yr				Ca	Mg	Na	Reference
						P	K						
Maritime Wales	<i>Picea sitchensis</i>		T				9.4			21.7	22.8	132.2	Potts, 1978 ¹
N. Carolina, USA	<i>Picea, Abies</i>	50	T				16.8			7.3	1.8		Weaver, 1972
			S				.7			.4	.6		
Tennessee, USA	<i>Pinus</i>		T		10.6	0.37	19.65			26.25	3.8		Henderson et al., 1977 ¹
Ontario, Canada	<i>Pinus banks.</i>	30	T		.01	.12	10.00			6.56	1.12		Foster, 1974
	<i>Pinus banks.</i>	30	S		5.13	.01	1.60			.58	.13		
Tennessee, USA	<i>Pinus echinata</i>	30	T&S		2.9	.3	18.7			17.4	2.8		Harris in Cole & Rapp, 1980
Grabels, France	<i>Pinus halep.</i>		T		1.1	.6	8.0			11.6	2.7	20.2	Rapp, 1969
Nevada, USA	<i>Pinus jeffrey</i>		T&S		9.61	2.03	6.83			5.17	2.72	0.33	Stark, 1973 ¹
New Zealand	<i>Pinus nigra</i>		T				8.41			0.94	1.53	18.72	Will, 1955, 1959 ¹
							25.78			4.82		81.54	
							1.27			3.24		29.62	
Scotland	<i>Pinus nigra</i>	40	T		8	.13	28			12	12	98	Miller, Cooper and
			S		1	.02	4			4	3	22	Miller, 1976
NW Spain	<i>Pinus radiata</i>		T		15.2		76.1			20.5	13.9	57.6	Calvo de Anta et al., 1979 ¹
											Cl 69.8		
											S04-S 41.6		
											H2O 857		
New York, USA	<i>Pinus resinosa</i>		T&S good site			0.39	3.7			6.0	1.16		Yarney et al., 1978 ¹
			poor site			0.35	3.5			5.0	1.27		
Virginia, USA	<i>Pinus strobus</i>		T				5.17			4.15	0.73	3.58	Parker, 1982 ¹
											Cl 2.52		
											S04-S 6.27		
S. Carolina, USA	<i>Pinus strobus</i>						30.5			6.3	2.0	7.2	Best & Monk, 1975 ¹
N. Carolina, USA	<i>Pinus strobus</i>	15	T&S				28.0			2.0			Swank in Cole & Rapp, 1980
N. Carolina, USA	<i>Pinus strobus</i>	60-200	T&S				24.1						Swank in Cole & Rapp, 1980

Table 9 Throughfall & Stemflow

Location	Dom. Veg.	Age	T/S ¹	C	N	Input kg/ha/yr			Ca	Mg	Na	Reference
						P	K					
S. Norway	Pinus sylv.		T			0.0	6.8		3.7	1.9 C1 S04-S	12.3 21.9 7.8	Hornbvedt and Joranger, 1974 ²
S. Sweden	Pinus sylv.		T				10.34		14.89	3.62 C1 S04-S	11.4 22.90 21.91	Richter & Granat, 1978 ¹
							5.89		9.33	1.79 C1 S04-S	10.5 21.69 13.46	
										NH4-N NO3-N	1.48 6.43	
C. Scotland	Pinus sylv.		T						10.0	5.4 S04-S	29.0	Nicholson et al. 1980 ³
Finland	Pinus sylv.	28 S	T S		4.82 .10	.08	5.78 .23		7.44 .44			Malonen, 1974
N. Carolina, USA	Pinus taeda	11 32	T T		9.3 3.7	0.5 0.3	11.7 6.6		4.5 6.5	1.8 1.8		Jorgensen et al. 1980
N. Carolina, USA	Pinus taeda		T&S		4.54	0.74	9.60		9.79	2.37 NO4-N NO3-N	0.76 2.08	Wells et al. 1972 ¹
N. Carolina, USA	Pinus taeda		T		4.61 4.44 3.71 8.60	0.37 0.36 0.34 0.48	4.06 3.54 6.56 11.24		4.14 4.28 5.61 4.90	1.15 1.42 1.83 1.85		Wells & Jorgensen, 1975, Wells et al. 1975 ¹
										S04-S NH4-N NO3-N	9.89 1.49 2.47	
							10.06		4.10	1.76 S04-S NH4-N NO3-N	12.70 0.74 2.45	
Georgia, USA	Pinus taeda				8.48	0.52						
N. Carolina, USA	Pinus taeda		T		1.0 2.7	.30 .26	5.08 5.07		.0 .1	.08 .89		Torrenewva, 1975 ¹ Wells et al. 1975
Shiga, Japan	Pinus, Chamaecyparis Chamaecyparis		T S T S		4.43 .31 19.59 17.76	1.08 .04 1.76 1.53	21.0 .77 41.17 34.97		25.55 2.0 20.7 14.46	5.80 .41 7.58 6.37	9.72 .95 15.69 14.88	Tsutsuami, 1978

Table 9 Throughfall & Stemflow

Location	Dom. Veg.	Age	T/S	C	N	Input kg/ha/yr			Ca	Mg	Na	Reference
						P	K					
New Brunswick, Canada	Populus grand.	44	S	3.03	.20		2.07		.88	.18	.20	Mahendrapa, 1974
New Mexico, USA	Populus trem.	T					3.23	2.23		0.36	0.24	Graustein, 1980
										Cl	1.36	
	Picea engelmanni									S04-S	1.64	
	Abies concolor						6.0	5.2		N03-N	0.31	
										0.82	0.62	
										Cl	3.7	
										S04-S	4.21	
Minnesota, USA	Populus trem.	T&S			8.62	1.54	18.28	18.66		4.02	1.34	Verry & Timmons, 1977
										NH4-N	1.97	
										N03-N	1.64	
Oregon, USA	Pseud. menz.	450	T		3.2	1.0	13.2	7.0		2.0		Grier in Cole & Rapp, 1980
Oregon, USA	Pseud. menz.		T		5.55							Tarrant et al. 1968
	Mixed		S		.09							
			S		3.69							
			S		.04							
New Zealand	Pseudotsuga		T			4.50	27.13	5.62			34.93	Will, 1959
Cedar Falls, Wash. USA	Pseudotsuga	30	T		1.10	.22	8.16	4.31		2.61		Rahman, 1964
		30	S		.16	.03	1.13	.81		.50		
Washington, USA	Pseudotsuga	22	T		2.9	1.8	7.0	5.2		1.5	Mn 1.7	Turner, 1975
		30	T		2.9	1.5	17.5	12.6		2.9	.5	
			S		.02	.01	.4	.2		.1	.02	
		42	T		3.7	1.3	7.5	5.4		1.0	.5	
		73	T		3.6	2.1	9.8	5.8		3.1	.9	
			S		.04	.01	.32	.23		.03	.01	
		95	T		1.2	1.11	11.1	8.6		.1	.5	
			S		.05	.02	.5	.3		.05	.01	
Washington, USA	Pseudotsuga	36	T		1.5	.3	10.7	3.5				Cole et al. 1967
			S		.2	.1	1.6	1.1				
		42	T				28.3	2.05		4.9		Grier & Cole, 1972
			S				4.0	3.8		.6		
Oregon, USA	Pseudotsuga		T		4.0	2.3	17.4	6.0		2.6		Abbe, 1973
	Tsuga mert.		T		3.0	2.4	15.7	4.4		2.0		
	Tsuga mert.		T		3.7	3.0	30.3	2.1		1.4		
	Tsuga mert.		T		2.7	3.3	23.4	5.1		2.3		

Table 9 Throughfall & Stemflow

Location	Dom. Veg.	Age	T/S ¹	C	N	P	K	Ca	Mg	Na	Reference
Oklahoma, USA	Quercus		T		14.3	2.07	15.0	12.1	2.77		Johnson Risser, 1974 ¹
Coastal England	Quercus		T&S			3.3	0.40	28.5	19.3	0.6	Brown, 1974 ¹
England	Quercus		T&S		8.82 9.31	1.31 0.92	28.14 29.74	17.18 20.98	9.36 13.23	55.55 89.36	Carlisle et al. 1966, 1967 ¹
Eastern France	Quercus				26	0.3	21.4	12.3			Aussenac et al. 1972 ¹
Belgium	Quercus		T S			.6 .0	16.0 .8	6.2 .9	5.6 .6		Duvigneaud & Denaeyer-de Smet, 1970
Minn. USA	Quercus Frax. Acer		T T		5.54 5.49	.66 .59		7.59 10.52	3.07 3.78		Reiners, 1972
France	Quercus ilex	150	T S		.5 1.2	1.6 .3	21.3 6.5	23.3 7.8	3.6 .8		Loissant in Cole & Rapp, 1980
Rouquet, France	Quercus ilex		T	-	.4	2.0	19.2	16.0	1.1	8.9	Rapp, 1969
Madeleine, France	Quercus ilex		T		9.6	3.1	38.2	23.2	4.8	20.0	Rapp, 1969
Gabrielac, France	Quercus lanu.		T		4.1	.2	12.7	1.1	2.4	9.3	Rapp, 1969
Belgium	Quercus mixed	115- 160	T S		2.2 .2		9.0 2.0		7.0		Duvigneaud, Denaeyer in Cole & Rapp, 1980
Hungary	Quercus petraea		T		21.30	2.34	28.51	26.76	5.01 C1 S04-S	2.41 15.41 49.64	Szabo & Csontos, 1975 ¹
Illinois, USA	Quercus prinus		T	-	.31	.10	5.04	1.58			Ostman and Weaver, 1979
Tennessee, USA	Quercus prinus		T		10.6	0.37	17.65	21.25	2.9		Henderson et al. 1977 ¹
NW Spain	Quercus robur		T		5.1		60.8	20.5	11.3 C1 S04-S H2O	42.7 35.8 33.9 780	Calvo de Anta et al. 1979 ¹
Bogle Crag Wood, England	Quercus pet.	uneven S	T S		8.82 -.01	1.31 .004	28.14 1.48	17.18 1.90	9.36 .58	55.55	Carlisle et al. 1966, 1967

Table 9 Throughfall & Stemflow

Location	Dom. Veg.	Age	T/S ¹	C	N	Input kg/ha/yr			Ca	Mg	Na	Reference
						P	K					
Virginia, USA	Quercus, Liriodendron		T				9.22	4.13		1.08 C1	4.24 3.02	Parker, 1982 ²
Tennessee, USA	Quercus, Carya		T		11.45	0.57	23.85	23.85		3.7		Henderson et al., 1977 ³
Illinois, USA	Quercus, Carya	150	T		3	1	21	12		4		Rolfe, Akhtar & Arnold, 1978
		S			1		16	13		1		
Tennessee, USA	Quercus, Carya	30- 80	T&S		12.4	.6	23.9	24.1		3.7		Harris in Cole & Rapp, 1980
	Quercus prinus	30- 80			11.6	.4	17.7	21.5		2.9		
Illinois, USA	Quercus, Carya, Liriodendron		T		.78 .19	3.15 .15	3.78 .24	6.64 1.28		.37 <0.01		Brown, 1980
Central Sweden	Scots pine		T				2.15	2.36		1.31 NH4-N	2.13	Bringmark, 1980 ⁴
										0.59 NO3-N	0.88	
							1.92	1.60		0.41 NH4-N	2.59 1.01	
										NO3-N	1.26	
USA?	Taxodium		T		9.6	1.29	10.4	13.3		6.9		Brinson et al., 1980
		S			0.71	0.26	1.56	9.59		0.70		
		T&S			10.31	1.55	11.96	15.31		7.60		
Minn., USA	Thuja occid.		T		6.05	.51		10.69		3.68		Reiners, 1972

¹T-Throughfall²S-Stemflow³Based on 9 months data⁴Cited in Parker 1983

Table 10 Litter Decomposition

Location	Dom. Veg.	Age	Component	Method	Component	K(%)	Reference
Hokkaido, Japan	Abies	Mixed	Total litter	In / mass	Weight	.107	Shidei & Tsutsumi, 1962
	Picea	30	Total litter	In / mass	Weight	.012	
	Picea & Abies	Mixed	Total litter	In / mass	Weight	.077	
	Abies	40	Total litter	In / mass	Weight	.045	
	Abies	40	Total litter	In / mass	Weight	.085	
	Abies	40	Total litter	In / mass	Weight	.123	
	Abies	40	Total litter	In / mass	Weight	.106	
	Abies	30	Total litter	In / mass	Weight	.067	
	Abies	30	Total litter	In / mass	Weight	.038	
	Abies amab.	175	Total		Weight	.56	
Washington, USA							Turner & Singer, 1976
New Hampshire, USA	Acer, Fagus		Betula	L.B.?	Weight	.85	Gosz et al., 1973
			Acer			.51	
			Fagus			.37	
Japan	Broad -mix ..lower slope		Total Litter	In / mass	Weight	1.55	Katagiri & Tsutsumi, 1978
					N	.85	
					P	1.22	
					K	7.10	
	Broad -mix -upper slope				Ca	1.36	
					Mg	2.09	
					Weight	.28	
					N	.15	
					P	.18	
					K	.81	
					Ca	.46	
					Mg	.43	
	Castanopsis -moist soil		Total Litter	In / mass	Weight	1.08	
					N	1.08	
					P	.87	
					K	2.54	
Japan	Cyclobal. -dry soil				Ca	.79	Katagiri et al., 1978
					Mg	1.48	
			Total Litter	In / mass	Weight	.26	
					N	.20	
					P	.19	
					K	.47	
					Ca	.49	
					Mg	.31	

Table 10 Litter Decomposition

Location	Dom. Veg.	Age	Component	Method	Component	K (%)	Reference
Japan	Chamaecyp.		Total Litter	In / mass	Weight N P K Ca Mg	.318 .340 .480 1.48 .500 .625	Kawahara, 1971
England, UK	Conifer		Pinus Picea Abies	L.B. ²	Weight	.65 .46 .46	Hayes, 1965
Kyoto, Japan	Cripto Fagus Quercus	50-60 mix mix	Total litter Total litter Total litter	In / mass In / mass In / mass	Weight Weight Weight	.303 .400 .545	Shidei & Tsutsumi 1962
N. Carolina, USA	Decid., mix		Total litter	L.B. ² (1 yr)	Weight N P K Ca Mg	.70 .12 .34 1.76 .34 1.46	Cromack & Monk, 1975
			Pinus Quercus Quercus Acer Cornus	C/N regress ¹	Weight	.43 .60 .72 .78 1.26	
Oregon, USA	Douglas-fir	430	Logs	Regress	Weight	.043 .0084	MacMillan et al. unpublished
Stradbroke Is. Qld, Australia	Eucalyptus	?	Total	L.B. ²	Weight	.24	Rogers & Westman, 1977
Maroondah, Victoria Australia	Eucalyptus regnans	38	Total	In/Biomass ⁴	Weight N P K Mg Ca Na	.26 .13 .27 .53 .30 .43 2.00	Feller, unpublished
					Weight	.52	
					N	.20	
					P	.51	
					K	1.08	
					Mg	.66	
					Ca	.67	
					Na	2.16	

Table 10 Litter Decomposition

Location	Dom. Veg.	Age	Component	Method	Component	K(%)	Reference
Mt. Disappoint., Victoria, Australia	Eucalyptus	even	Total litter	In/Biomass ^a	Weight P K Mg Ca Na Weight	.163 .165 .256 .245 .189 .484 .092 .269	Attiwill, 1968
Brisbane, Qld., Australia	Eucalyptus		Branch wood Leaves	L.B. ¹ (2 yrs) L.B. ² (2 yrs)	Weight Weight		Birk, 1977
			Overstory Pultenaea Acacia Grass Overstory Woody Pultenaea Acacia Grass	L.B. ² , Tether Tether Tether Quadrats In/Biomass ^a	Weight Weight .38 .50 .68 .24 2.42 .98 .13		
Kosciusko, NSW. Australia	Eucalyptus pauc.		Foliage	L.B. ¹ (1 yr)	Weight P N	.776-.633 .598-.431 2.302-1.204	Macauley, 1975
Tennessee, USA	Fagus Decid. Quercus		Mix Mix Mix			.43 ^a .511 ^a .616 ^a	
Japan	Fagus crenata		Total Litter	Input / mass	Weight N P K Ca Mg	.362 .395 .453 1.04 .316 .582	Kawahara, 1971
Roudsea Wood, UK	Fraxinus, Betula		Foliage-Birch Birch Lime Oak Oak Birch Birch Lime Oak Oak Birch Lime Oak Oak	L.B. ^a (6 mos)	Weight	1.772 2.405 .799 .301 .185 .301 .342 .248 .261 .186 .328 .288 .198 .248 .186	Bocock & Gilbert, 1957
	Quercus, Betula						
	Betula						

Table 10 Litter Decomposition

Location	Dom. Veg.	Age	Component	Method	Component	K (%)	Reference
Nagano, Japan	Larix	10	Total litter	In / mass	Weight	1.055	Shidei & Tsutsumi, 1962
	Larix	28	Total litter	In / mass	Weight	.296	
	Larix	48	Total litter	In / mass	Weight	.264	
Tennessee, USA	Liriodendron Quercus	48	Liriodendron	C/N regress ¹	Weight	.690	Ausmus & Witkamp, 1974
			Fraxinus			.986	
			Carya			.927	
			Quercus			.630	
			Acer			.897	
			Cornus			1.105	
			Branches			.304	
			Flowers			1.253	
			Roots			1.135	
			Liriodendron	Lignin regress ¹	Weight	.852	
			Fraxinus			.768	
			Carya			.788	
			Quercus			.707	
Japan	Magnolia		Cornus			.883	Kawahara & Sato, 1974
			Branches			1.152	
			Flowers			.385	
			Roots			.844	
						.925	
			Foliage	L.B. ²	Weight	.654 ³	
			Foliage	Tether		1.05-1.514 ³	
Japan	Cyclobalanopsis			L.B. ²	Weight	.431 ³	Kawahara, 1975
				Tether		.916 ³	
				L.B. ²	Weight	.58 ³	
New Brunswick, Canada	Mix decid.		Larix			.635 ³	MacLean, 1978
			Chamaecypar			.635 ³	
			Mixed				
	Mix decid.		Acer foliage	L.B. ²	Weight	.46-.87	
			Prunus fol.			.47-.90	
			Populus fol.			.31-.48	
			Betula fol.			.48-.70	
			Acer branch			.06-.11	
			Prunus branch			.04-.10	
			Populus branch			.20-.30	
			Betula branch			.10-.19	
			Understory			.43-1.25	
			Forest floor			.19-.27	

Table 10 Litter Decomposition

Location	Dom. Veg.	Age	Component	Method	Component	K (%)	Reference
Kumamoto, Japan	Pinus	40	Total litter	In / mass	Weight	.169	Shidei & Tsutsumi 1962
	Pinus	11	Total litter	In / mass	Weight	.100	
Hyogo, Japan	Pinus	60	Total litter	In / mass	Weight	.109	Shidei & Tsutsumi 1962
Hiroshima Japan	Pinus	mix	Total litter	In / mass	Weight	.212	Shidei & Tsutsumi 1962
	Pinus	mix	Total litter	In / mass	Weight	.143	
Shiga, Japan	Pinus	150	Total litter	In / mass	Weight	.133	Shidei & Tsutsumi 1962
	Chamae.	30	Total litter	In / mass	Weight	.675	
	Chamae.	30	Total litter	In / mass	Weight	.660	
	Chamae.	30	Total litter	In / mass	Weight	.500	
	Chamae.	30	Total litter	In / mass	Weight	.165	
Tennessee, USA	Pinus		Foliage	L.B. ² Tether	Weight	.47 .10	Witkamp & Olson, 1963
Japan	Pinus		Quercus	L.B. ²	Weight	.58 ¹	Kawahara, 1975
			Pinus	L.B. ²		.616 ¹	
			Mixture	L.B. ²		.616 ¹	
New Brunswick, Canada	Pinus banksiana	29	Needles	L.B. (2 yr)	Weight	.28	MacLean, 1978
			Branches			.03	
		57	Needles			.23	
			Branches			.08	
Japan	Pinus densiflora		Total Litter	In / mass	Weight	.405	Kawahara, 1971
					N	.226	
					P	.116	
					K	.226	
					Ca	.079	
					Mg	.211	
					Weight	.47	
Japan	Pinus densiflora		Needles	L.B.	Weight	.20	Kawahara & Sato, 1977
			Branches 1-2 cm	Tether	Weight	.12	
			5-6 cm	Tether	Weight	.07	
			9-10 cm	Tether	Weight	.20	
			Roots .9 cm	L.B.	Weight	.16	
			2.5 cm	3 yr	Weight	.14	
			5.5 cm	3 yr	Weight	.14	

Table 10 Litter Decomposition

Location	Dom. Veg.	Age	Component	Method	Component	K(%)	Reference
Nevada, USA	Pinus jeffreyi				Weight	.11	Stark, 1973 ¹
Netherlands	Pinus nigra	22	Total	In/Biomass ⁴	C		Minderman, 1968
	Pinus sylvestris	85	Total	In/Biomass ⁴	Cellulose	.058 .111	
					C	.0165 .070	
California, USA	Pinus ponderosa	150 50	Total Total	In/Biomass ⁴	Weight	.029 .029	Jenny et al., 1949
New Zealand	Pinus radiata		Total Litter -clearcut -stand	L.B. ^{2,3}	Weight	1.14 1.17 .89 .82	Gadgil & Gadgil 1978
N. Carolina, USA	Pinus strobus Mix dec.		Needles Quercus Quercus Acer Cornus	L.B.	Weight Weight Weight Weight Weight	.46 .61 .72 .77 1.26	Cromack & Monk, 1973
N. Carolina, USA	Pinus strobus			L.B. ²	Weight	.42-.52	Cromack, 1972 ¹
Tennessee, USA	Pinus taeda	19	Needles Cornus fol. Mixed	L.B. ² (1 yr)		.58 ¹ 1.27 ¹ .58 ¹	Thomas, 1968
Tennessee, USA	Pinus virginiana Pinus taeda				Weight	.45-.46 .51-.58	Sollins et al., 1973 ¹
Finland	Pinus, Betula		Foliage	L.B. ²	Weight Weight	.26-.40 .30-.46	Mikola, 1960 ¹
Alberta, Canada	Populus		P. tremuloid P. balsamifera	L.B. ² (1 yr) L.B. ² (5 yr) L.B. ² (1 yr) L.B. ² (5 yr) Tether	Weight Weight	.292 .113 .264 .131 .485	Lousier & Parkinson, 1976

Table 10 Litter Decomposition

Location	Dom. Veg.	Age	Component	Method	Component	K(%)	Reference
Alberta, Canada	Populus trem.		Epilobium against stems	L.B. (1 yr)	Weight	.848 .16 .377	Krauler, 1976
Alaska, USA	Populus, Betula		Populus Betula	L.B.?	Weight	.34-.48 .38-.52	Van Cleave, 1971
Oregon, USA	Pseudotsuga	450	Tsuga logs Pseudo. logs	Known age Known age	Weight Weight	0.025 0.012	Graham 1981
Washington, USA	Pseudotsuga	450	Boles	In / mass	Weight	0.028	Sollins, 1982
Washington, USA	Pseudotsuga	22 30 30 42 73	Total litter	In/Biomass	Weight	.134 .164 .231 .150 .092	Turner & Long, 1975
B.C., Canada	Pseudotsuga dry mesic moist dry mesic moist	120	Needles Forest Floor	L.B. (1 yr) In/Biomass	Weight Weight Weight Weight Weight	.43 .43 .43 .015 .017 .040	de Catanzaro, 1979
Oregon, USA	Pseudotsuga		Needles Branches Cones Bark	L.B.?	Weight	.22-.31 .059-.089 .047-.083 .005-.040	Fogel & Cromack, 1977
Netherlands	Quercus	Old	Total	In/Biomass	C	.019	
California, USA	Quercus	50-100	Total	In/Biomass	Weight	.117	Jenny et al., 1949
Tennessee, USA	Quercus		Acer	L.B.?	Ca Ca Weight Ca Weight Ca	.55 .54 .44 .38 .33 .35	Thomas, 1970
			Liriodendron				
			Quercus				

Table 10 Litter Decomposition

Location	Dom. Veg.	Age	Component	Method	Component	K(%)	Reference
Tennessee, USA	Quercus		Foliage	L.B. ¹	Weight	.70	Lemee & Bichaut, 1973
				Tether		1.67	
	Acer		Foliage	L.B. ²		.64	
				Tether		1.47	
Fontainebleau, France	Liriodendron		Foliage	Tether		3.22	Lemee & Bichaut, 1973
	Quercus		Total	In/Biomass ⁴	Weight	.31-.46	
				L.B. ²	Weight	.20-.66	
Netherlands	Quercus			L.B. ¹ (1 yr)	Phenols	.100	Minderman, 1968
				In/Biomass ⁴		.105	
				L.B. ²	Waxes	.25	
				In/Biomass ⁴		.29	
				L.B. ²	Lignin	.50	
				In/Biomass ⁴		.69	
				L.B. ²	Cellulose	.75	
				In/Biomass ⁴		1.38	
				L.B. ²	Hemicell	.90	
				In/Biomass ⁴		2.30	
Tennessee, USA	Quercus alba Pinus echinata Acer rubrum		Mixed (ave)	L.B. ² (1 yr)	Sugars	.99	Witkamp, 1966
						4.60	
					Weight	1.021	
						1.021	
Missouri, USA	Quercus alba		Total litter	In/Biomass ⁴	N	.188	Rochow, 1975
					P	.230	
					K	.340	
					Ca	.197	
Oregon, USA	Tsuga het. Picea sit.	121	Logs	Volume loss	Mg	.238	Grier, 1978
					Weight	.008	
						.004	

¹ From Fogel and Cromack, 1977

² Litter bag

³ Based on Cromack, 1972

⁴ Based on Jenny et al (1949)

⁵ Calculated from percent weight loss $x/x_0 = \exp(-kt)$

Table 11 Annual Uptakes (kg/ha/yr)

Location	Vegetation	Age	Comp.	N P K Ca Mg					Other	Reference
England	Abies grandis	20		30-75						
Korea	Alnus sibirica	2	Total	120	12	70				Ovington, 1957a
USSR	Betula	35 20		146 84						Mun et al. 1977 Bazilevich
USSR	Betula	42		135						Smirnova & Gorodentseva, 1958
England	Betula	6-55		56	4.1	28	5.6	4.1	Na .6	Ovington, 1959a
Finland	Betula	40	Tree	109.6	10.9	47.8	77.1			Malkonen 1977
Oregon, USA	Bryophyte in Pseudotsuga forest	450		4.05	0.74	1.36	3.32	0.27		Binkley and Graham 1981
Norway	Bryophyte in conifer plantation			10.0	1.1	4.0	4.0			Tamm 1953
Canada	Bryophyte in conifer plantation			5.0	1.0	3.5	.9	.5		Westman & Timmer 1967
Great Britain	Bryophyte in oakwood					14.0	3.9- 4.4	3.6- 4.2		Rieley et al 1979
Japan	Chamaecyparis			49.4	3.8	18.9	64.7	8.6		Kawahara 1971
England	Conifers			8-38						Ovington 1957a
Stradbroke Is. Qld, Australia	Eucalyptus	?	Tree Underst.	18 4.0	21 5.6	19 4.8	15 0.9	22 2.3	Na 16 0.7	Westman, 1978
C. Europe	Fagus			58.2	5.8	34.4	27.2	3.5	5 8.5	Ulrich, 1975
Minnesota, USA	Fagus	?		50	13	15	96			Bakuzis 1971
Japan	Fagus cren.			54.7	4.2	15.8	61.7	9.2		Kawahara 1971
C. Europe	Fagus sylvatica	120		144						Rodin & Bazilevich, 1967
Germany	Fagus sylvatica	90		70						Ebermayer, 1876

Table 11 Annual Uptakes (kg/ha/yr)

Location	Vegetation	Age	Comp.	N	P	K	Ca	Mg	Other	Reference
Soiling, W. Germany	Fagus sylvatica	125		71.9	4.89	45.9	33.3	3.20	Cl 27.5 Fe 3.70 Mn 6.03 Na 5.7 S 35.8	Ulrich & Mayer 1972
Sweden, Norway	Hylacomium splendens (Moss)		Total	10	1.1	4	4	4		Tamm 1953
England	Larix	20		16-33						Ovington, 1957a
England	Larix decidua	45		<11						Ovington, 1957a
Japan	Mixed broad -lower slope -upper slope			108.2 41.8	9.69 2.64	76.5 31.2	226.7 83.5	28.9 10.7		Katagiri et al 1978
Kyoto, Japan	Mixed broad Chamaecyparis			86.7 31.9	4.2 1.3	98.6 21.1	95.5 61.7	26.3 9.3		Iwatsubo 1976
Wales	Mosses		Total			14	4.2	3.9		Rieley 1979
New Zealand	Nothofagus			40	3.3	34	84	12		Miller, 1963
USSR	Picea			61 62	3.2 2.7	18 12	56 48	9 7		Sonn, 1960 ¹
England	Picea abies	20		44-49						Ovington, 1957a
USSR	Picea exc.	72 55		30 114						Remezov et al, 1959 ¹
USSR	Picea exc.	125		47						Rudnova et al. ¹
USSR	Picea exc.	200		75						Marchenko & Karlov, 1961 ¹
England	Picea omo.	47		11-18						Ovington, 1957a
England	Picea omo.			48	5	32	24	5	Na 1.8	Ovington, 1961
USSR	Picea sylv.	120		19						P'yavchenko, 1960 ¹

Table 11 Annual Uptakes (kg/ha/yr)

Location	Vegetation	Age	Comp.	N	P	K	Ca	Mg	Other	Reference
Germany	Pine	20		18.57	1.31	5.04	10.73	1.80	Si .85	Ramann, 1887 ¹
		60		10.60	1.25	2.68	7.10	1.17	.44	
	Spruce	120		7.75	.44	1.92	5.50	.87	.33	
		20		15.15	1.38	5.57	8.37	2.10	.65	
		60		18.45	1.34	6.12	13.90	2.20	.68	
		120		13.70	1.78	4.34	11.36	1.53	.47	
Minnesota, USA	Pinus	7		45	5	7	29			Bakuzis 1971
Japan	Pinus dens.			38.8	3.8	14.3	38.7	5.6		Kawahara 1971
England	Pinus nigra	20-43		20-43						Ovington, 1957a
		47		9-14						
Scotland	Pinus nigra	40		17-	4.4-	14-	26-	7.6-		Miller, Miller & Pauline 1976
				187	9.2	44	36	11.1		
New Zealand	Pinus rad.	0-22		13	1.5	13	8.9	3.5	Na .3	Madgwick et al 1977
									Mn .3	
									Zn .15	
		2-4		62	7.9	48	24.4	10.5	Na .6	
									Mn 1.0	
		8-10		43	7.4	44	5.9	13.9	Zn .32	
									Na .5	
									Mn .4	
									Zn .32	
Central Sweden	Pinus sylv.	120-140	Tree abovegr.	6.5	0.6	3.5	6.9	1.1	Na 0.6	Bringmark 1977
									S 1.4	
			belowgr.	10.0	2.0	9.2	5.7	2.5	Na 0.4	
									S 2.2	
			Understory	16.5	2.0	4.1	4.5	1.0	Na 0.32	Ebermayer, 1876 ¹
									S 2.9	
Germany	Pinus sylv. Picea exc.	80 90		48 48						Malkonen, 1974
Finland	Pinus sylv.	28		19.0	2.5	9.8	11.1			
		47		28.2	3.1	11.2	11.6			
		45		38.8	4.2	17.9	19.4			

Table 11 Annual Uptakes (kg/ha/yr)

Location	Vegetation	Age	Comp.	N	P	K	Ca	Mg	Other	Reference
England	Pinus sylv.	20-23		180	13	65	83	18	Na 11	Ovington, 1959b
England	Pinus sylv.			139	11	58	56	12		Ovington, 1959a
Quebec, Canada	Pleurozium shreberi (Moss)		Total	5	1.0	3.5	.9	.5		Weetman & Timmer 1967
USSR	Populus	25 50		143 154						Remezov et al., 1959 ¹
Washington, USA	Pseudotsuga	22	Tree	27.6	11.2	30.2	29.3	9.2	Mn 7.0	Turner, 1975
			Underst.	16.7	2.8	19.9	20.0	4.9	1.6	
		30	Tree	27.4	6.4	30.0	46.7	8.7	8.3	
			Underst.	6.6	.5	8.3	12.5	2.8	2.0	
		42	Tree	34.0	10.1	32.9	42.0	9.8	7.3	
			Underst.	7.3	.5	8.0	12.8	2.3	1.8	
		73	Tree	24.0	2.4	24.6	41.0	5.4	7.3	
			Underst.	3.7	1.5	2.6	6.1	.3	1.8	
		95	Tree	12.1	2.7	27.7	52.4	5.1	7.8	
			Underst.	2.3	.7	1.7	3.5	.9	1.4	
Washington	Pseudotsuga menziesii	45	Control	17						Turner 1977
			Low fer.	31						
			High	63						
			fert.							
			Carbohy.	4						
			fert.							
Oklahoma, USA	Quercus	80	Total	103.0	11.0	81.6	304.2	23.9	Mn 12.3	Johnson & Risser, 1974
Korea	Quercus acutissima	12		131	13	112				Mun et al., 1977
Minnesota, USA	Quercus	7		88	70	79	56			Bakuzis 1971
USSR	Quercus robur	43 220		91 83						Mina, 1955 ¹
USSR	Quercus robur	12 48		80 104						Remezov et al., 1959 ¹
USSR	Tilia cord.	40 74		105 131						Remezov et al., 1959 ¹

¹In Rodin & Bazilevich, 1967²In Ovington, 1962

Table 12 Nutrient Concentrations - Overstory (% of dry weight)

Location	Species	Age	Component	N	P	K	Ca	Mg	Other	Reference
N.W. USA	Acer saccharum	70	Foliage-mid crown	1.98- 2.32	0.10- 0.12	0.55- 0.74	0.86- 1.02	0.14- 0.16	Mn766-1175, Na 58-82, Fe 59-73, Zn 32-71, Al 32-38, Cu 3-5, Co 3-6	Lea et al. 1980
Prince George, B.C. Canada	Abies lasiocarpa	110- 350	Wood (stem divided 9 into 10 equal sections)	.060 .065 .055 .054 .064 .050 .040 .050 .049 .050 .530 .42 .38 .36 .36 .31 .32 .35 .33 .16 .20	.005 .002 .005 .005 .002 .004 .005 .004 .002 .002 .085 .075 .059 .059 .058 .060 .055 .054 .074 .07 .045	.123 .118 .137 .144 .127 .086 .075 .070 .063 .061 .18 .16 .15 .14 .15 .14 .13 .14 .13 .08 .119	.155 .159 .165 .204 .144 .100 .080 .075 .075 .070 .680 .89 .90 .83 .81 .80 .85 .93 .97 .95 .59 .56	.029 .029 .033 .047 .035 .023 .018 .017 .016 .019 .094 .088 .077 .095 .082 .070 .062 .058 .048 .031 .052 .050	Kimmins, 1974	
			Bark Top10	.42 .38 .36 .36 .31 .32 .35 .33 .16 .20	.075 .059 .059 .058 .060 .055 .054 .074 .07 .045	.16 .15 .14 .15 .14 .13 .14 .13 .08 .119	.89 .90 .83 .81 .80 .85 .93 .97 .95 .59 .56	.088 .077 .095 .082 .070 .062 .058 .048 .031 .052 .050		
			Branches>2.5 2.5>0.6cm. Twigs & Foliage Upp.crown Mid.crown Low.crown	.70 .72 .67	.14 .15 .16	.22 .25 .22	.50 .50 .61	.077 .080 .096		
B.C., Canada	Abies amabilis		current needles	.91- .99	.12- .16	1.2- 1.10	.30- .41	.07- .08	S 1200, S .06 B 26, Zn 33, Fe 40, Mn 825	Beaton et al. 1965
Oregon	Abies amabilis		Leaves	.18	.18	1.05	.43	.12	S .06 B 26, Zn 33, Fe 40, Mn 825	Will & Youngberg, 1979

Table 12 Nutrient Concentrations - Overstory (% of dry weight)

Location	Species	Age	Component	N	P	K	Ca	Mg	Other	Reference
New York, USA	Abies balsamea						1.15			Chandler, 1944
B.C., Canada	Abies balsamea	300+	Wood	.05	.01	.06	.06	.01		Krumlik, 1978
			Bark	.24	.04	.13	.49	.03		
			Large branch	.15	.02	.09	.31	.02		
			Small branch	.22	.03	.12	.29	.03		
			Fol+twigs	.74	.10	.33	.44	.07		
Maine, USA	Abies balsamea		Branches	.31	.11	.36	.84	.08		Young, 1971
			Stem	.28	.06	.23	.53	.06		
			Stump+roots	.25	.07	.19	.64	.06		
USA	Abies balsamea		Needles	1.955	.187	.662	.661	.120	Cu 10.9, Fe 294, Mn 1125, Na 313, Zn 335	Stark, 1973
California, USA	Abies concolor	8	Current needles low elev. site	1.38	0.12	1.23	0.53	0.14	Mn 89.3	Isik 1978
			Current needles mid elev. site	1.41	0.11	1.10	0.33	0.10	Mn 54.5	
			Current needles high elev. site	1.13	0.18	1.09	+0.32	0.14	Mn 195.7	
Oregon	Abies grandis		Foliage	.14	.14	1.00	.45	.12	S .06 B 23, Zn 31, Fe 50, Mn 790	Will & Youngberg, 1979
Idaho, USA	Abies grandis	20-30, Fert.	Needles-new	1.29	.19	.90				Loewenstein & Pitkin 1971
			Needles-old	1.00	.14	.58				
			Branches-new	.98	.18	.86				
			Branches-old	.52	.08	.42				
			Bark	.52	.10	.50				
			Stem	.11	.01	.10				
		unfert.	Needles-new	1.18	.19	1.09				
			Needles-old	1.06	.15	.81				
			Branches-new	.88	.15	.92				
			Branches-old	.43	.06	.34				
			Bark	.50	.07	.48				
			Stem	.08	.01	.08				

Table 12 Nutrient Concentrations - Overstory (% of dry weight)

Location	Species	Age	Component	N	P	K	Ca	Mg	Other	Reference
Prince George, B.C., Canada	<i>Abies lasioc.</i>	110- 125	Aerial: Wood	18.0	8.4	46.9	21.0	37.1		Kimmins, 1974
			Bark	76.3	31.4	19.8	41.3	24.9		
			Live crown	55.7	60.2	33.3	37.7	38.0		
Montana, USA	<i>Abies lasioc.</i>		Wood & bark <15 cm dbh	0.11	0.05	0.10	0.34	0.02	Cu 9.1 ¹ Fe 72 ¹ Mn 152 ¹ Na 29 ¹ Zn 12 ¹ Cu 10.6 ¹ Fe 28 ¹ Mn 111 ¹ Na 8 ¹ Cu 9.2 ¹ Fe 39 ¹ Mn 123 ¹ Na 20 ¹ Zn 10 ¹	Stark, 1979
			Wood & bark 15-30 cm dbh	0.16	0.07	0.07	0.31	0.002		
			Wood & bark >30 cm dbh	0.26	0.04	0.11	0.25	0.003		
B.C., Canada	<i>Abies lasioc.</i>	3-6	current needles	1.05- 1.85	.18- .26	.70- 1.08	.29- .44	.07- .11	S 1200-1600 ¹	Beaton et al. 1965
			Current leaves	2.1	.04	.6	.90	.18	Na .12 S .13	Westman & Rogers, 1977
			Older leaves	2.3	.08	.8	.60	.16	Na .15 S .14	
N.E. USA	<i>Acer rubrum</i>	70	Foliage-mid crown	1.72- 1.93	0.08- 0.13	0.54- 0.79	0.80- 1.12	0.14- 0.20	Mn867-1316 ¹ Na 75-112 ¹ Fe 54-65 ¹ Zn 38-77 ¹ Al 29-66 ¹ Cu 4-6 ¹ Co 3-6 ¹	Lea et al. 1980
New York, USA	<i>Acer rubrum</i>						.91			Chandler, 1944
			Branches	.69	.07	.24	1.38	.05		Young, 1971
			Stem	.51	.06	.20	1.23	.04		
Southeast USA	<i>Acer rubrum</i>		Stump+roots	.41	.11	.37	2.01	.07		
				0.14	0.64	1.00	0.20	Lignin 12.7		Sharpe et al. 1980

Table 12 Nutrient Concentrations - Overstory (% of dry weight)

Location	Species	Age	Component	N	P	K	Ca	Mg	Other	Reference
USA	Acer rubrum		Leaves	.790	.179	.556	.687	.100	Cu 11.3, Fe 146, Mn 2388, Na 367, Zn 46.5	Stark, 1973
Southeast USA	Acer saccharum			0.33	1.17	1.64	0.28	Lignin 15.0		Sharpe et al., 1980
New York, USA	Acer saccharum					1.75				Chandler, 1944
USA	Acer saccharum		leaves	1.926	.122	.750	1.020	.230	Cu 10.5, Fe 254, Mn 1250, Na 348, Zn 44.2	Stark, 1973
New Hampshire, USA	Acer saccharum		Leaves Twigs Branches Stem bark Light wood Dark wood Roots	2.19 .18 .07 .55 .10 .10 .71	.18 .18 .07 .03 .01 .004 .37	1.01 .93 .17 .29 .07 .30 .27	.60 1.62 .43 1.41 .10 .32 .25	.12 .10 .03 .06 .02 .06 .05	S	Likens & Bormann, 1970
New Hampshire, USA	Acer spic.		Leaves Twigs Branches Bark Light wood Dark wood Roots	2.49 .14 .48 .76 .07 .12 .82	.20 .14 .10 .09 .008 .004 .10	1.33 .56 .18 .16 .04 .07 .23	.75 1.17 .46 1.36 .09 .08 1.25	.13 .12 .05 .06 .01 .02 .07		Likens & Bormann, 1970
New York, USA	Acer spp. May 27 June 26 July 26 Aug 26 Sept 25			2.31 1.89 1.89 1.85 1.80	.29 .24 .23 .23 .23	1.28 .81 .69 .69 .68	.74 1.19 1.04 1.17 1.37			Tryon, 1936
Minnesota, USA	Alnus crispa	6	Leaves	0.23	0.74	0.91	0.24		Fe 239, Cu 9.1, Zn 38, Mn 700	Grigal et al., 1979

Table 12 Nutrient Concentrations - Overstory (% of dry weight)

Location	Species	Age	Component	N	P	K	Ca	Mg	Other	Reference
Minnesota, USA	<i>Alnus crispa</i>		Leaves	2.28	0.16	0.56	1.07	0.24	Fe 115 ¹ Cu 3.5 ² Zn 12 ³ Mn 318 ³ Al 77 ³ Na 7.6 ³ B 21 ³	Henry 1973
UK	<i>Alnus inc.</i>	21	Leaves	2.65	.36	1.66	2.46	.27	Na .04	Ovington, 1956a
Oregon, USA	<i>Alnus rubra</i>	?	Senescent leaves	2.10					Lignin 9.5 Cellulose 80.6	Cromack et al. 1979
			Bolt wood	0.17					Lignin 19.4 Cellulose 29.5	
			Roots (2-5 mm)	0.75					Lignin 17.4 Cellulose 48.0	
B.C., Canada	<i>Alnus rubra</i>	23	Leaves	2.87	0.29	0.91	0.77	0.19	S 0.28	Binkley 1982
			Branches	0.64	0.02	0.27	0.28	0.11		
			Stems	0.21	0.01	0.10	0.08	0.02	S 0.02	
Washington, USA	<i>Alnus rubra</i>	2	Leaves	2.96	0.23	0.85	0.64	0.19	Fe 100 ¹ Mn 100 ¹	Hughes et al. 1968
Korea	<i>Alnus sibirica</i>	12	Leaves	1.33	0.19	0.84				Mun et al. 1977
			Branches	0.56	0.05	0.10				
			Trunks	0.44	0.02	0.06				
			Roots	0.68	0.03	0.55				
B.C., Canada	<i>Alnus sinuata</i>	23	Leaves	5.97	0.35	0.79	0.77	0.19	S 0.29	Binkley 1982
			Stems	0.21	0.01	0.05	0.05	0.02	S 0.02	
B.C., Canada	<i>Alnus sinuata</i>	5	Leaves	2.51	0.39	0.85	1.13	0.19		Binkley 1982
			Stems	0.64	0.15	0.23	0.21	0.04		
			Roots	0.64	0.15	0.23	0.24	0.04		
N. Stradbroke Australia	<i>Banksia aemula</i>		Primary branch bark	.19	.005	.14	.350	.298	Na .298	Westman & Rogers 1977
			Secondary branch wood	.11	.005	.02	.225	.085	.107	
			Secondary branch bark	.26	.005	.07	.375	.240	.155	
			Tertiary (termi.) branch wood	.26	.028	.23	.400	.070	.179	
			Tertiary (termi.) branch bark	.25	.014	.25	.425	.192	.226	
			Root crown wood	.22	.005	.02	.200	.040	.067	
			Root crown bark	.26	.005	.04	.225	.064	.167	
			Tap root wood	.11	.005	.01	.125	.026	.061	
			Tap root bark	.24	.005	.02	.225	.070	.095	
			Lateral root wood	.10	.006	.04	.050	.025	.107	
			Lateral root bark	.16	.006	.02	.125	.070	.160	
			Flowers	.8	.08	.5	.08	.08	Na .14 S .08	
			Current leaves	.7	.05	.4	.14	.08	Na .15 S .08	

Table 12 Nutrient Concentrations - Overstory (% of dry weight)

Location	Species	Age	Component	N	P	K	Ca	Mg	Other	Reference
New Hampshire, USA	<i>Betula alleghaniensis</i>		Older leaves	1.0	.04	.4	.13	.10	Na .13 S .10	Likens & Bormann, 1970
			Stem wood	.1	.005	.01	.150	.021	Na .074	
			Stem bark	.20	.005	.05	.350	.123	Na .202	
			Primary branch wood	.10	.005	.05	.200	.044	Na .071	
			Leaves	2.78	.20	1.14	.88	.25	.14	
			Twigs	.21	.52	.16	.96	.16	.04	
			Branches	.44	.03	.10	.42	.03	.04	
			Stem bark	.60	.03	.13	.96	.04	.04	
			Light wood	.08	.01	.03	.06	.01	.02	
			Dark wood	.10	.01	.11	.09	.02	.02	
N.E. USA	<i>Betula alleghaniensis</i>	70	Roots	.61	.08	.14	.37	.04	.07	Lea et al., 1980
			Foliage-mid crown	2.45- 2.63	0.12- 0.15	0.80- 0.96	0.92- 1.18	0.23- 0.30	Mn 1070-1650, Na 65-145, Fe 69-87, Zn 399-439, Al 62-87, Cu 6-7, Co 4-6	
UK	<i>Betula alba</i>	21	Leaves	1.44	.33	1.09	1.99	.29	.03	Ovington, 1956a
New York, USA	<i>Betula lutea</i>						1.21			Chandler, 1944
	<i>Betula lutea</i>		leaves	2.055	1.360	.731	.757	.320	Cu 12.0, Fe 335, Mn 286, Na 372, Zn 125	Stark, 1973
N.E. USA	<i>Betula papyrifera</i>		Leaves							Lang et al., 1982
			Late summer	2.79	0.193	0.937	0.233	0.113	Na 0.0056	
			Leaf fall	2.47	0.168	0.500	0.384	0.148	Na 0.0060	
			Twigs	2.31	0.157	0.121	0.311	0.121	Na 0.0038	
			Wood							
			Branch 1-5 cm	0.222	0.034	0.089	0.082	0.027	Na 0.0017	
			Branch 5-10 cm	0.128	0.022	0.066	0.072	0.027	Na 0.0026	
			Bole	0.115	0.009	0.040	0.084	0.020	Na 0.0012	
			Roots							
			<1 mm	1.51	0.082	0.182	0.182	0.066	Na 0.0025	
			1-5 mm	1.10	0.068	0.170	0.187	0.068	Na 0.0021	
			0.5-1 cm	0.85	0.052	0.142	0.138	0.051	Na 0.0016	
			1-2.5 cm	0.61	0.039	0.119	0.107	0.043	Na 0.0013	
			>2.5 cm	0.48	0.038	0.087	0.105	0.037	Na 0.0010	

Table 12 Nutrient Concentrations - Overstory (% of dry weight)

Location	Species	Age	Component	N	P	K	Ca	Mg	Other	Reference
Maine, USA	Betula papyrifera		Branches	.67	.04	.10	1.05	.05		Young, 1971
			Stem	.53	.04	.10	1.04	.04		
			Stump+roots	.35	.06	.16	.89	.06		
UK	Betula verr.		Leaves	2.85	.17	1.56	1.57	.27		Ovington & Madgwick, 1959a
			Stem	.14	.01	.07	.25	.02		
USSR	Betula verr.		Leaves	2.36	.19	.73	1.13	.67	S .08	Bazilevich
			Stem	.26	.02	.07	.13	.04	.01	
			Fine roots	1.46	.11	.17	.60	.16	.07	
Minamata, Japan	Broad-mixed		Leaf	1.48	.081	.59	.55	.19		Katagiri et al., 1978
			Branch	.50	.042	.30	.46	.10		
			Stem	.16	.009	.17	.19	.03		
Japan	Broad, decid.		Foliage	2.4-	.12-	.7-	.6-			Tsutsumi 1971
	Needles, decid.		Foliage	2.9	.33	1.4	2.0			
			Foliage	2.0-	.14-	.5-	.4-			
	Pinus		Foliage	2.5	.22	1.0	1.0			
			Foliage	.9-	.05-	.4-	.5-			
	Broad evergr.		Foliage	1.2	.13	.9	1.0			
			Foliage	1.3-	.07-	.5-	.6-			
	Needle, evergr.		Foliage	1.9	.11	1.0	1.2			
			Foliage	.9-	.06-	.3-	.5-			
	Cryptomeria		Foliage	1.5	.19	.5	1.4			
			Foliage	.9-	.08-	.4-	.6-			
				1.3	.13	.8	1.4			
USSR	Carpinus bet.		Leaves	.13	.13	1.35	1.49	.33	Na .36	Dzens-Litovskaya, 1960
			Stem+branch		.02	.28	.54	.11	S .07	
									Na .05	
Southeast USA	Carya			0.07	0.83	1.71	0.24	Lignin 16.9	S .02	Sharpe et al., 1980
New York, USA	Carya alia						2.62			
New York, USA	Carya cord.						2.50			
New York, USA	Carya ovata						1.94			Chandler, 1944
USA	Carya ovata		Leaves	1.189	.237	.862	.687	.231	Cu 12.9; Fe 438; Mn 3580; Na 215; Zn 345;	Stark, 1973

Table 12 Nutrient Concentrations - Overstory (% of dry weight)

Location	Species	Age	Component	N	P	K	Ca	Mg	Other	Reference
USA	<i>Castanea dentata</i>		Leaves	1.472	.255	.750	.807	.162	Cu 9.9, Fe 100, Mn 1325, Na 325, Zn 31.3	Stark, 1973
UK	<i>Castanea sat.</i>		Leaves	2.59	.17	.95	.57	.22	.05	Ovington, 1956a
UK	<i>Castanea sat.</i>	46	Leaves	2.50	.22	1.10	.67	.29	.02	Ovington, 1956a
Oregon, USA	<i>Ceanothus velut.</i> ?		Leaves	1.78						Cromack et al., 1979
			Stems	0.36						
			Roots	0.43						
			Nodules	2.37						
Haney, B.C.	<i>Chamaecyparis nootkatensis</i> , <i>Thuja plicata</i>		Branches	20.0	15.4	9.2	22.4			Kimmins & Krumlik, 1976
			Stembark	17.1	15.4	24.5	34.6			
			Stemwood	22.9	38.4	54.1	20.6			
Maine, USA	<i>Chamaecyparis</i>		Branches	.38	.04	.05	2.28	.07		Young, 1971
			Stem	.28	.02	.08	2.45	.07		
			Stump+roots	.31	.06	.16	2.22	.09		
UK	<i>Chamaecyparis</i>	20	Needles	.92	.06	.30	1.02	.19	.03	Ovington, 1956a
Czechoslovakia	<i>Cornus sanguinea</i> L.		Buds	5.018	.884	1.741	1.117	.312	Ash 7.619	Klino, 1975
			Leaves	2.367	.272	1.390	2.554	.630	Ash 11.409	
			Fruits	1.275	.323	1.312	.276	.116	Ash 3.850	
			Fruit-stalks	1.267	.222	2.084	.850	.211	Ash 6.726	
			Annual shoots	1.720	.322	.774	.936	.253	Ash 4.614	
			Branches <5mm	.930	.192	.516	.641	.149	Ash 6.160	
			Branches 5-10mm	.825	.144	.165	.459	.100	Ash 2.845	
			Stem-Wood	.614	.084	.160	.182	.050	Ash 1.703	
			Stem-Bark	1.556	.222	.714	.218	.143	Ash 6.955	
			Roots <1mm	1.275	.188	.664	.799	.419	Ash 7.523	
			Roots 1-2mm	.878	.171	.387	.638	.235	Ash 3.927	
			Roots 2-5mm	1.008	.169	.277	.513	.166	Ash 2.995	
			Roots 5-20mm	.993	.167	.246	.404	.134	Ash 3.199	
			Stumps	.450	.056	.191	.378	.073	Ash 1.839	
Southeast USA	<i>Cornus florida</i>			0.14	1.24	1.80	0.55	Lignin 3.9		Sharpe et al., 1980

Table 12 Nutrient Concentrations - Overstory (% of dry weight)

Location	Species	Age	Component	N	P	K	Ca	Mg	Other	Reference
UK	<i>Corylus</i> < 1 cm		Total	.97	.07	.20	1.10	.06	.018	Sykes & Barr, 1973
				.55	.03	.11	.58	.02	.007	
				.38	.02	.06	.50	.01	.004	
				.32	.02	.06	.48	.01	.003	
				.32	.02	.06	.55	.02	.003	
				.29	.02	.08	.41	.02	<.003	
				.28	.02	.08	.34	.02	<.003	
Japan	<i>Cryptomeria</i> -moist soil	1	Foliage	1.51	.57	1.01				Harada, 1970
			Twig	1.41	.46	.95				
			Stem	.37	.10	.36				
		3	Root	.52	.11	.36				
			Foliage	.97	.34	1.08				
			Twig	1.38	.18	.67				
		5	Branch	.50	.11	.20				
			Stem	.35	.06	.22				
			Root	.52	.06	.37				
		12	Leaf	1.16	.25	.84				
			Twig	.73	.39	1.04				
			Branch	.46	.11	.20				
	<i>Cryptomeria</i> -dry soil	1	Stem	.25	.05	.17				
			Root	.30	.05	.24				
			Leaf	1.13	.25	.64				
		3	Twig	.57	.16	.46				
			Branch	.26	.09	.18				
			Stem	.12	.02	.14				
		5	Root	.30	.05	.25				
			Leaf	1.33	.43	.01				
			Twig	1.38	.34	.92				
		12	Stem	.44	.11	.44				
			Root	.65	.11	.55				
			Leaf	.86	.30	.76				

Table 12 Nutrient Concentrations - Overstory (% of dry weight)

Location	Species	Age	Component	N	P	K	Ca	Mg	Other	Reference
Australia	<i>Eucalyptus umbra</i> ssp. <i>umbra</i>		Primary	.30	.005	.09	.225	.039	.090	Westman & Rogers, 1977
			branch bark							
			Secondary	.12	.005	.01	.200	.001	.029	
			branch wood							
			Secondary	.30	.012	.14	.300	.117	.131	
			branch bark							
			Tertiary (termi.)	.44	.010	.07	.250	.060	.100	
			branch wood							
			Tertiary (termi.)	.42	.014	.14	.700	.230	.143	
			branch bark							
			Root crown wood	.22	.005	.01	.100	.001	.033	
			Root crown bark	.37	.005	.03	.375	.018	.071	
			Tap root wood	.17	.004	.01	.100	.010	.040	
			Tap root bark	.35	.008	.03	.325	.020	.071	
Ise, Mie Pref Japan	Evergr. Br. L.		Lateral root wood	.38	.024	.09	.100	.044	.071	Tsutsumi et al. (unpublished).
			Lateral root bark	.34	.013	.13	.400	.090	.107	
			Current leaves	1.25	.08	.6	.18	.16	.15	
								Na	5	
			Older leaves	1.1	.05	.5	.355	.20	.14	
								Na	5	
			Live stem wood	.20	.005	.01	.150	.003	.076	
			Dead stem wood	.23	.005	.03	.175	.043	.064	
			Live stem bark	.31	.005	.07	.550	.042	.210	
			Dead stem bark	.41	.005	.02	.350	.110	.060	
			Primary	.19	.005	.02	.175	.001	.026	
			branch wood							
N.E. Thailand	Evergr. Br. L.		Leaf	1.57	.102	.88	.52	.35		Tsutsumi et al. 1967
			Branch	.38	.071	.29	.38	.11		
			Stem	.19	.035	.16	.17	.06		
Minamata, Japan	Evergreen Br. L.		Leaf	1.78	.094	.84	1.16	.49		Kawahara 1971
			Branch	.61	.041	.35	.76	.19		
			Stem	.25	.015	.18	.44	.25		
Kumamoto, Japan	Evergreen Br. L.		Leaf	1.22	.082	.68	.89	.35		Tsutsumi, Kan & Khemanark 1967
			Branch	0.34	.034	.18	.50	.07		
			Stem	0.14	.012	.13	.26	.04		
	Evergreen Br. L.		Leaves	1.52	.086	.83	1.19	.89		
			Branches	.47	.033	.50	.86	.30		
			Stem	.16	.011	.23	.32	.15		

Table 12 Nutrient Concentrations - Overstory (% of dry weight)

Location	Species	Age	Component	N	P	K	Ca	Mg	Other	Reference
Hitoyoshi, Kumamoto Pref Japan	Evergreen Br.L.		Leaf Branch Stem	1.92 .57 .20	.078 .039 .009	.59 .30 .13	0.65 0.64 .31	.29 .14 .04		Shidei et al. (unpublished)
N.E. USA	Fagus grand.	70	Foliage-mid crown	2.47- 2.48	0.11- 0.13	0.71- 0.84	0.73- .77	0.18- 0.19	Mn925-1764, Na 60-223, Fe 86-92, Zn 37-68, Al 32-60, Cu 5-7, Co 2-4	Lea et al., 1980
Southeast USA	Fagus grandifolia				0.03	0.31	0.84	0.07	Lignin 19.2	Sharpe et al., 1980
New York, USA	Fagus grandifolia						.75			Chandler, 1944
USA	Fagus grandifolia		Leaves	1.355	.142	1.247	1.047	.170	Cu 15.5, Fe 222, Mn 1875, Na 320, Zn 23	Stark, 1973
New Hampshire, USA	Fagus grandifolia		Leaves Twigs Branches Bark Light wood Dark wood Roots	2.23 .30 .75 .11 .12 .64	.18 .20 .03 .04 .01 .002 .12	.88 .58 .12 .22 .07 .10 .24	.55 1.23 .47 2.53 .06 .36	.15 .23 .03 .05 .02 .02 .05	.17 .05 .03 .03 .04	Likens & Bormann, 1970
USSR	Fagus orien.		Leaves	.30	1.20	1.40	.43	.16	S	Dzhafarov, 1960
Australia	Fagus regnans		stemwood stem bark live branches dead branches leaves roots	.02 .13 .12 .12 1.29 .18	.002 .016 .009 .004 .105 .018	.18 .36 .38 .05 .86 .44	.02 .10 .04 .03 .23 .13	.03 .63 .26 .19 .49 .05	Na .01 .06 .02 .02 .09 .08	Feller, 1981
UK	Fagus sylv.	38	Leaves	2.57	.18	.99	.97	.19		Ovington, 1956a
Germany	Fagus sylv.		Leaves Branches Stem	1.71 .70 .36	.60 .06 .02	1.73 .04 .07	.73 .42 .32	.23 .08 .04	S .10 tr. tr.	Ebermayer, 1876

Table 12 Nutrient Concentrations - Overstory (% of dry weight)

Location	Species	Age	Component	N	P	K	Ca	Mg	Other	Reference
UK	Fraxinus < 1 cm			.79	.08	.56	.77	.08	.012	Sykes & Barr, 1973
	1			.50	.04	.31	.54	.05	.008	
	2			.31	.02	.18	.41	.03	<.003	
	3			.26	.02	.14	.40	.03	<.003	
	4			.22	.02	.13	.32	.02	<.003	
	6			.19	.01	.11	.32	.02	<.003	
	8			.18	.01	.11	.31	.02	.004	
	10			.16	.01	.09	.22	.02	.005	
	12			.15	.01	.10	.14	.01	.006	
	> 12			.16	.01	.11	.14	.01	<.003	
Czechoslovakia	Fraxinus		Leaves	2.68	.34	2.24	2.26	.51	Ash12.02	Klino, 1975
			Annual shoots	1.10	.15	.81	.79	.17	Ash 3.90	
			Branches <2cm							
			Bark	1.00	.06	.66	1.75	.14	Ash 5.08	
			Wood	.69	.05	.17	.16	.03	Ash .60	
			Branches 2-5cm							
			Bark	.89	.06	.56	1.27	.08	Ash 3.53	
			Wood	.63	.04	.18	.24	.04	Ash 1.05	
			Branches >5cm							
			Bark	.57	.03	1.11	1.55	.12	Ash 4.48	
			Wood	.62	.03	.23	.27	.04	Ash 1.44	Sharpe et al., 1980
			Stem - Bark	.59	.03	.57	1.95	.11	Ash 4.80	
			Stem - Wood	.27	.02	.27	.08	.03	Ash .69	
			Underground parts							
			O-0.1cm	1.39	.12	.16	.22	.29	Ash19.41	
			O.1-1cm Bark	.98	.05	.72	1.37	.36	Ash10.50	
			Wood	.55	.10	.30	.49	.25	Ash 3.03	
			1-2cm Bark	1.08	.05	.71	1.15	.22	Ash14.97	
			Wood	.65	.07	.13	.22	.06	Ash 1.41	
			2-5cm Bark	.70	.07	.76	1.36	.21	Ash14.27	
			Wood	.30	.03	.06	.19	.04	Ash 1.49	Chandler, 1944
			5-10cm Bark	.77	.04	.51	2.70	.28	Ash14.39	
			Wood	.54	.09	.13	.13	.07	Ash 1.26	
			>10cm Bark	.66	.08	.60	1.17	.19	Ash12.31	
			Wood	.49	.07	.09	.23	.06	Ash 1.30	
				0.09	0.86	2.82	0.29	Lignin 16.8		
Southeast USA	Fraxinus						2.19			
New York, USA	Fraxinus amer.									
USSR	Fraxinus excel.									
			Leaves	1.36	.51	1.88	1.96	.43	S	Remezov et al., 1959
			Branches	.71	.21	.58	.70	.08		
			Stem	.24	.07	.30	.32	.03		

Table 12 Nutrient Concentrations - Overstory (% of dry weight)

Location	Species	Age	Component	N	P	K	Ca	Mg	Other	Reference
Southeast USA	<i>Gleditsia triacanthos</i>			0.35	1.65	1.12	2.14	1.02	Lignin 25.1	Sharpe et al. 1980
Southeast USA	<i>Juglans nigra</i>			0.31	1.12	1.12	2.14	1.02	Lignin 6.6	Sharpe et al. 1980
USA	<i>Juniperus utahensis</i>		needles	.778	.106	.447	1.463	.137	Cu 9.2, Fe 114, Mn 17, Na 395, Zn 7.8	Stark, 1973
Southeast USA	<i>Juniperus virg.</i>			0.05	0.41	0.41	4.64	0.12	Lignin 22.8	Sharpe et al. 1980
Southeast USA	<i>Kalmia latifolia</i>			0.01	0.30	0.30	1.58	0.18	Lignin 21.5	Sharpe et al. 1980
USA	<i>Larix laricina</i>		needles	1.762	.165	.387	.700	.132	Cu 9.9, Fe 378, Mn 458, Na 313, Zn 25	Stark, 1973
UK	<i>Larix lept.</i> <i>Tsuga heter.</i> <i>Pseudotsuga</i> <i>Picea omor.</i> <i>Pinus nigra</i> <i>Larix decl.</i> <i>Pinus sylv.</i> <i>Abies gran.</i> <i>Larix lept.</i>		Needles	2.32 1.98 1.27 1.07 1.15 2.16 1.46 1.24	.18 .12 .09 .08 .07 .22 .13 .21	.50 .47 .38 .32 .38 .48 .56 .46 .47	.54 .38 .74 .52 .74 .61 .62 .91 1.03	.16 .13 .17 .13 .12 .17 .09 .16 .12	Na .04	Ovington, 1956z
Montana, USA	<i>Larix occidentalis</i>		Wood & bark <15 cm dbh	0.12	0.07	0.07	0.14	0.02	Cu 8.7, Fe 39, Mn 167, Na 24, Zn 13	Stark, 1979
			Wood & bark 15-30 cm dbh	0.06	0.05	0.04	0.11	0.006	Cu 9.5, Fe 56, Mn 71, Na 17, Zn 42	
			Wood & bark >30 cm dbh	0.05	0.04	0.04	0.12	0.01	Cu 9.0, Fe 33, Mn 81, Na 23, Zn 10	

Table 12 Nutrient Concentrations - Overstory (% of dry weight)

Location	Species	Age	Component	N	P	K	Ca	Mg	Other	Reference
Germany	Larix sp.	100	Needles Stem	1.26 .20	.22 .01	.66 .04	.74 .06	.21 .01	S S tr.	Ebermayer, 1876
Southeast USA New York, USA	Liquidambar styr. Liriodendron Juniperus virg.		Leaves		0.28	0.98	1.44	0.43	Lignin 14.2	Sharpe et al., 1980 Chandler, 1944
Southeast USA	Liriodendron tulip.				0.23	1.18	1.55	0.47	Lignin 14.6	Sharpe et al., 1980
UK	Nothofagus	21	Leaves	2.60	.15	.87	.91	.21	.03	Ovington, 1956a
Southeast USA	Nyssa sylvatica				0.10	0.58	1.26	0.86	Lignin 14.0	Sharpe et al., 1980
New York, USA	Ostrya virg.						2.27			Chandler, 1944
USSR	Picea	200	needles 1st. yr. Branches Bark Wood Fine roots	1.60 1.00 .89 .47 1.22	.14 .04 .04 .004 .14	.88 .24 .29 .06 .26	.31 .26 .86 .07 .44	.14 .07 .08 .02 .17		Rodin & Basilevich, 1967
USSR	Picea	90- 120	needles 1st. yr. Branches Wood & Bark	1.28 .57 .16	.09 .08 .08	.71 .04 .04	.14 .30 .01	.09 .08 .01		Rodin & Basilevich, 1967
B.C., Canada	Picea englemann.	3-6 200- 250	current needles	1.26- 1.72 .92- 1.08	.21- .29 .12- .20	.71- .80 .70- .88	.44- .58 .28- .33	.13- .15 .11- .12	S 1300-1900; S 1200-1400;	Beaton et al., 1965
Sweden	Picea	25	Needles-N April 17-S July 16-N S Oct 19-N S	1.33 1.20 1.12 1.04 1.34 1.26	.13 .11 .10 .08 .15 .12	.59 .51 .58 .47 .81 .60	.87 .78 1.26 1.00 1.67 1.28		S1 .45 .36 .72 .55 .95 .71	Tamm, 1955
UK	Picea abies	46	Needles	1.40	.12	.46	.98	.11	.03	Ovington, 1956a
UK	Picea abies	46	Needles	1.53	.12	.50	.66	.09	.06	Ovington, 1956a

Table 12 Nutrient Concentrations - Overstory (% of dry weight)

Location	Species	Age	Component	N	P	K	Ca	Mg	Other	Reference
UK	Picea abies	19	Needles	1.43	.10	.41	.64	.13	.02	Ovington, 1956a
Quebec, Canada	Picea abies -good		Needles-top	1.32	.27	.61	.40	.21		Stewart & Swan, 1962
	Picea abies -poor		Needles-top -lower	1.08 1.40 1.19	.20 .23 .22	.59 .64 .43	.35 .33 .38	.16 .14 .14		
Sweden	Picea abies	30	Stem wood	.063	.056	.05	.076	.009	Mn	Tamm, 1955
			bark	.51	.080	.34	.87	.066	Mn	
			Branches	.42	.056	.25	.41	.043	Mn	
			Needles	1.15	.150	.62	.58	.102	Mn	
			Dead branches	.50	.040	.068	.53	.026	Mn	
USA	Picea abies		Needles	1.02	.09	.39	1.96	.23		
	Picea rubr.		Needles	.89	.10	.35	.79	.20		
Montana, USA	Picea engelmann.		Wood & bark <15 cm dbh	0.08	0.03	0.09	0.21	0.01	Cu 8.8, Fe 179, Mn 81, Na 20, Zn 21, Cu 9.0, Fe 36, Mn 77, Na 22, Zn 24, Cu 9.3, Fe 26, Mn 71, Na 24, Zn 12,	Lutz & Chandler, 1947 Stark, 1979
			Wood & bark 15-30 cm dbh	0.10	0.05	0.10	0.33	0.02		
			Wood & bark >30 cm dbh	0.14	0.07	0.05	0.16	0.009		
New York, USA	Picea excel.						1.60			Chandler, 1944
Germany	Picea excel.	90-120	Needles -1 yr	1.28	.09	.71	.14	.09	Na .05 S .03	Ebermayer, 1876
			Branches	.57	.08	.27	.30	.08	Na .02 S .03	
			Stem+bark	.16	tr.	.04	.01	.01	Na tr. S tr.	
USSR	Picea excel.	120	Cones	.36	.03	.27	.02	.07	Na .01 S .01	Manakov, 1961
			Needles	.84	.07	.38	.52	.07	Na .03 S .03	
			Branches	.74	.05	.24	.30	.07	Na .03 S .02	
			Stem	.09	.02	.04	.09	.02	Na .005 S .01	

Table 12 Nutrient Concentrations - Overstory (% of dry weight)

Location	Species	Age	Component	N	P	K	Ca	Mg	Other	Reference
USSR	Picea excel.	200	Needles < 1 yr	1.60	.19	.88	.31	.14	S	Marchenko & Karpov, 1962
			Branches	1.00	.04	.24	.26	.07	S	
			Bark	.89	.04	.29	.86	.08	S	
			Stem	.47	.004	.06	.07	.02		
			Fine roots	1.22	.14	.26	.44	.17		
USSR	Picea excel.		Needles < 1 yr	1.62	.09	1.35	.47	.16	S	Parshevnikov, 1959a
			3 yr	1.56	.08	.62	.64	.14		
			5 yr	1.54	.08	.55	.81	.14		
			8 yr	1.53	.07	.46	1.17	.14		
USSR	Picea excel.		Needles < 1 yr	1.60	.14	.88	.31	.14	S	Marchenko & Karpov, 1962
			2 yr	1.36	.15	.64	.74	.19		
Prince George, B.C. Canada	Picea glauca	110-125	Aerial: Wood	25.4	12.6	48.5	22.1	30.4		Kimmins, 1974
			Bark	41.4	33.9	23.9	52.2	38.1		
			Live crown	33.2	53.5	27.6	25.7	31.5		
Prince George, B.C. Canada	Picea glauca	110-350	Wood (stem divided 9 into 10 equal sections)	.059	.005	.053	.10	.011		Kimmins, 1974
			stump 1	.049	.005	.049	.085	.009		
			stump 10	.055	.005	.049	.095	.009		
			9	.060	.003	.050	.090	.008		
			8	.054	.002	.049	.099	.008		
			7	.040	.005	.050	.120	.010		
			6	.049	.002	.047	.075	.007		
			5	.049	.002	.050	.090	.007		
			4	.050	.002	.047	.065	.005		
			3	.050	.003	.047	.050	.005		
			2	.320	.043	.122	.730	.068		
			Bark	.38	.044	.122	.82	.067		
			9	.23	.035	.105	.92	.065		
			8	.26	.035	.107	1.02	.061		
			7	.25	.035	.096	1.14	.056		
			6	.25	.030	.096	1.10	.050		
			5	.22	.030	.093	1.16	.050		
			4	.24	.025	.095	1.03	.043		
			3	.22	.020	.093	1.20	.046		
			2	.23	.025	.089	1.25	.045		
			1	.16	.010	.070	.52	.028		
			Branches > 2.5cm	.30	.035	.105	.70	.047		
			Branches 2.5-0.6	.58	.075	.183	.58	.074		
			Twigs Upp.crown	.62	.085	.197	.47	.077		
			Twigs Mid.crown	.62	.105	.215	.42	.077		
			Low.crown							
			Foliage							
			Upp.crown	1.07	.146	.229	.28	.064		
			Mid.crown	.92	.140	.204	.32	.064		
			Low.crown	.90	.135	.236	.28	.074		

Table 12 Nutrient Concentrations - Overstory (% of dry weight)

Location	Species	Age	Component	N	P	K	Ca	Mg	Other	Reference
USSR	Pinus	95	Needles	1.29	.16	.45	.34	.10		Rodin & Basilevich 1967
			Branches	.49	.07	.32	.48	.07		
			Wood	.11	.01	.10	.09	.02		
Oregon	Pinus ponderosa		Foliage	.22	.90	.20	.20	.10	S .06 B .22 Zn .36 Fe .25 Mn .11 S .08 B .24 Zn .35 Fe .25 Mn .11 S .06 B .21 Zn .34 Fe .30 Mn .18 S .08 B .25 Zn .38 Fe .35 Mn .10 S .08 B .30 Zn .47 Fe .25 Mn .14	Will & Youngberg 1979
				.20	1.00	.20	.20	.09		
				.23	1.05	.22	.22	.10		
				.23	1.30	.23	.23	.09		
				.25	.97	.21	.21	.12		
Quebec, Canada	Pinus banksiana		Needles-top	1.58	.20	.54	.31	.11		Stewart & Swan, 1962
	-good		-lower	1.41	.16	.51	.31	.11		
	Pinus banksiana		Needles-top	1.45	.16	.49	.27	.09		
	-poor		-lower	1.45	.16	.42	.27	.08		
USA	Pinus banksiana		needles	1.716	.177	.587	.281	.130	Cu 9.6 Fe 153 Mn 60 Na 308 Zn 43.8	Stark, 1973
Ontario, Canada	Pinus banksiana	20-65	Needles-top	.99	.13	.31	.26	.06		Morrison, 1973
			midle	.95	.11	.26	.29	.06		
			lower	1.04	.07	.39	.30	.07		
			Branches-top	.29	.02	.19	.19	.05		
			midle	.24	.02	.17	.18	.03		
			lower	.27	.01	.14	.19	.02		
			dead	.23	.01	.04	.12	.01		
			Stembark	.24	.02	.16	.37	.03		
			Stemwood-top	.10	.01	.08	.07	.01		
			midle	.06	.004	.05	.07	.01		
			lower	.07	.005	.06	.07	.01		
			Cones-new	.21	.04	.11	.02	.01		
			old	.23	.02	.04	.03	.01		

Table 12 Nutrient Concentrations - Overstory (% of dry weight)

Location	Species	Age	Component	N	P	K	Ca	Mg	Other	Reference
USA	Pinus monophylla		needles	1.000	.122	.536	.525	.187	Cu 8.6 ¹ Fe 65 ¹ Mn 30 ¹ Na 341 ¹ Zn 16.5 ¹	Stark, 1973
Montana, USA	Pinus monticola		Wood & bark <15 cm dbh	0.06	0.02	0.02	0.10	0.02	Cu 6.4 ¹ Fe 33 ¹ Mn 42 ¹ Na 30 ¹ Zn 12 ¹	Stark, 1979
			Wood & bark 15-30 cm dbh	0.06	0.02	0.02	0.08	0.02	Cu 5.9 ¹ Fe 37 ¹ Mn 31 ¹ Na 25 ¹ Zn 7 ¹	
			Wood & bark	0.06	0.02	0.02	0.08	0.02	Cu 5.8 ¹ Fe 26 ¹ Mn 67 ¹ Na 33 ¹ Zn 8 ¹	
UK	Pinus nigra	21	Needles	.87	.09	.43	.95	.11	.02	Ovington, 1956a
UK	Pinus nigra	46	Needles		.09	.41	.47	.10	.01	Ovington, 1956a
Scotland	Pinus nigra	40	Needles Twigs Live branch Dead branch Bark-upper Bark-lower Wood-upper Wood-lower Stump Roots	.9-2.3 .5-1.5 .2-.34 .20 .34-1.19 .16-.37 .07-.21 .04-.08 .05-.14 .25-.70						Miller & Williams 1968
UK	Pinus nigra		Needles < 1 yr 2 yr ≥ 3 yr	1.48 1.42 1.30	.17 .15 .15	.71 .61 .54	.30 .70 .95	.20 .14 .12	Na .04 .07 .13	Wright & Will, 1958
Royce Mtn. Oregon, USA	Pinus ponderosa		Foliage	.23	1.30	.22	.09	.09	S .08 B 24 ¹ Zn 38 ¹ Fe 35 ¹ Mn100 ¹	Will & Youngberg 1979

Table 12 Nutrient Concentrations - Overstory (% of dry weight)

Location	Species	Age	Component	N	P	K	Ca	Mg	Other	Reference
Arizona	Pinus ponderosa	60	current needles Basalt med. site sandstone poor site	1.00	.18	1.30	.52	.34		Binkley (unpublished)
Arizona	Pinus ponderosa	43	current needles unthinned Med. thinning Heavy thinning	1.34 1.85 2.02	.1 .13 .12	.71 1.25 1.14	.42 .6 .82	.25 .29 .37	S 1800 ¹ Zn 108 ¹ Mn 151 ¹ S 2500 ¹ Zn 98 ¹ Mn 66 ¹ S 2900 ¹ Zn 111 ¹ Mn 72 ¹	Wollum & Schubert 1975
New Zealand	Pinus radiata		Needles < 1 yr Needles 1-2 yr Needles 2-3 yr Needles 3-4 yr Needles 4-5 yr Foliage	1.12 1.06 1.01 .99 .96 1.15	.17 .18 .20 .25 .26 .13	.96 .90 1.01 .85 .92 .73	.14 .27 .29 .35 .57 .25	.17 .17 .18 .18 .22 .15	Na .02	Will, 1957
New Zealand	Pinus radiata	(av. 127 plots)								Mead & Will 1976
New Zealand	Pinus radiata	26	Needles Branches Bark Wood	1.32 .30 .17 .05	.16 .02 .02 .007	.90 .20 .17 .06	.12 .15 .13 .03			Orman & Will, 1960
New Zealand	Pinus radiata	2-22	Foliage	1.50	.17	.83	.27	.13	Na 61 ¹ Mn204 ¹ Zn 50 ¹	Madgwick et al, 1977
			Cones	.47	.07	.16	.022	.036	Na 41 ¹ Mn 11 ¹	
			Strobili	1.41	.21	.94	.05	.11	Zn 12 ¹ Na 36 ¹ Mn 43 ¹ Zn 41 ¹	
New York, USA	Pinus resin.						.80			Chandler, 1944

Table 12 Nutrient Concentrations - Overstory (% of dry weight)

Location	Species	Age	Component	N	P	K	Ca	Mg	Other	Reference
USA	Pinus resin.		Needles	.68	.07	.30	.76	.18		Lutz & Chandler, 1947
Quebec, Canada	Pinus resin. -good		Needles-top	1.45	.20	.56	.28	.14		Stewart & Swan, 1962
	Pinus resin. -poor		Needles-top -lower	1.26 1.31 1.15	.19 .23 .20	.65 .39 .32	.27 .38 .38	.13 .11 .12		
New York, USA	Pinus rigida		Stem heart	.10	.002	.02	.10	.01	.009	Woodwell et al., 1975
			Stem sap	.09	.007	.05	.08	.03	.01	
			Stem bark	.23	.06	.12	.11	.09	.05	
			Inner bark		.15	.48	.16	.12	.10	
			Outer bark		.04	.01	.14	.01	.06	
			Live branch	.18	.04	.11	.19	.08	.04	
			Dead branch	.37	.01	.01	.04	.006	.05	
			Twigs	.58	.12	.36	.12	.07	.10	
			Leaves	.90	.04	.32	.22	.07	.21	
			Fruits	.13	.03	.05	.01	.03	.03	
			Flowers	1.13	.24	1.09	.03	.08	.20	
			Root crown	.14	.02	.06	.06	.02	.02	
			Root wood		.03	.13	.04	.02	.07	
			Root bark		.04	.08	.05	.03	.06	
			Small roots		.06	.28	.10	.18	.18	
			Tab root		.02	.07	.03	.02	.03	
Southeast USA	Pinus rigida			0.10	0.32	0.55	0.08		Lignin 31.5	Sharpe et al., 1980
USA	Pinus stroba		needles	1.929	.132	.625	.525	.122	Cu 10.7, Fe 144, Mn 303, Na 313, Zn 41.5	Stark, 1973
New York, USA	Pinus strobis						1.20			Chandler, 1944
Maine, USA	Pinus strobis		Branches	.50	.07	.24	.83	.11		Young, 1971
			Stem	.37	.04	.13	.35	.06		
			Stump+roots	.24	.05	.10	.09	.04		
Maine, USA	Pinus strobis	43	Needles-top middle	.86	.14	.38	.06	.06		Young et al., 1967
			bottom	1.05	.16	.39	.10	.07		
			Needles-N	1.43	.20	.32	.21	.11		
			Needles-E	1.17	.17	.38	.13	.08		
			Needles-S	1.13	.18	.38	.13	.08		
			Needles-W	1.07	.16	.33	.12	.08		
			Needles-top middle	1.08	.17	.37	.12	.08		
			bottom	.94	.27	.49	.27	.09		
			Needles-N	.96	.22	.48	.23	.07		
			Needles-E	.97	.22	.57	.24	.07		
			Needles-S	.94	.23	.50	.24	.08		
			Needles-W	.99	.24	.52	.24	.08		
				.99	.25	.51	.26	.08		
				.96	.23	.52	.25	.07		
	Picea rubens	47								

Table 12 Nutrient Concentrations - Overstory (% of dry weight)

Location	Species	Age	Component	N	P	K	Ca	Mg	Other	Reference
Royce Mtn. Oregon USA	Pinus strobus		Foliage	.20	1.10	.24	.10	.09	S .30, B .30, Zn .45, Fe .45, Mn240	Will & Youngberg, 1979
Southeast USA	Pinus strobus			0.11	0.24	0.65	0.13	Lignin 31.0		Sharpe et al., 1980
New York, USA	Pinus sylv.					.69				Chandler, 1944
Quebec, Canada	Pinus sylv. -good Pinus sylv. -poor		Needles-top -lower Needles-top -lower	1.45 1.32 1.36 1.30	.20 .16 .21 .19	.57 .64 .41 .40	.31 .32 .34 .36	.09 .08 .13 .12		Stewart & Swan, 1962
Sweden	Pinus sylv.		Stem wood bark Live Branch Needles Dead Branch	.05 .26 .32 .92 .19	.004 .045 .037 .092 .011	.034 .17 .18 .30 .03	.053 .39 .28 .44 .24			Popovic & Burgdorf 1964
Germany	Pinus sylv.	80	Needles - 1 yr Needles - 3 yr Branches Stem+bark	1.56 1.18 .68 .15	.12 .03 .06 tr.	.53 .12 .26 .02	.14 .31 .23 .09	.08 .09 .08 .01	Na .02 S .03 Na .01 S .04 Na .02 S .02 Na .01 S tr.	Ebermayer, 1876
USSR	Pinus sylv.		Needles < 1 yr	1.36	.12	.56	.16	.17	Na .01 S .05 Mn .02 Fe .01 Al .05 Na .02 S .03 Mn .04 Fe .02 Al .08	Bazilevich
			Needles > 1 yr	1.12	.08	.28	.38	.16		
Finland	Pinus sylv.	28	Stem wood Bark Dead branch Live branch Needles - 1 yr Needles - 2 yr Needles - 3 yr Needles - 4 yr Cones Stumps Roots > 1 cm Roots < 1 cm	.06 .34 .34 .39 1.22 1.12 1.00 .80 .50 .10 .13	.006 .05 .02 .05 .15 .11 .10 .08 .08 .02 .02	.04 .19 .01 .22 .73 .42 .36 .31 .38 .08 .07	.06 .55 .31 .34 .21 .42 .55 .58 .04 .07			Maltonen, 1974
	Pinus sylv.	75 47	Stem wood Bark Dead branch	.48 .07 .38 .32	.10 .005 .06 .02	.27 .22 .22 .04	.07 .05 .32 .17			

Table 12 Nutrient Concentrations - Overstory (% of dry weight)

Location	Species	Age	Component	N	P	K	Ca	Mg	Other	Reference
USSR	Pinus sylv.	95	Live branch	.43	.05	.18	.24			
			Needles - 1 yr	1.27	.15	.58	.16			
			2	1.22	.13	.47	.27			
			3	1.20	.12	.38	.32			
			4	1.18	.12	.39	.37			
			Cones	.37	.05	.22	.02			
			Stumps	.09	.01	.07	.06			
			Roots > 1 cm	.09	.01	.08	.06			
			< 1 cm	.50	.08	.30	.15			
			Needles	1.29	.16	.45	.34	.10	Na .02 S .11	Remezov et al, 1959 ¹
S. Carolina, USA	Pinus taeda	17	Branches	.49	.07	.32	.48	.07	Na .01 S .10	
			Stem	.11	.01	.10	.09	.02	Na .01 S .01	
			Fine roots	.36	.06	.15	.33	.07	Na .02 S .14	
			Foliage	1.05	0.10	0.37	0.27	0.09		Van Lear, 1980
Southeast USA	Pinus taeda		Needles-upper middle lower	.76	0.11	0.32	0.59	0.07	Lignin 31.4	Sharpe et al, 1980
				.83	.10	.42	.37	.09		Wells & Metz, 1963
Mississippi, USA	Pinus taeda	4	Foliage	1.00						
			Branches	.41						
			Stembark	.42						
			Stemwood	.16						
			Foliage	.95						
			Branches	.24						
			Stembark	.24						
			Stemwood	.06						
			Foliage	1.08						
			Branches	.23						
		30	Stembark	.23						
			Stemwood	.06						
			Foliage	1.22						
			Branches	.22						
		56	Stembark	.19						
			Stemwood	.04						
			Foliage	1.16						
			Branches	.21						
Stembark	.17									
Stemwood	.03									

Table 12 Nutrient Concentrations - Overstory (% of dry weight)

Location	Species	Age	Component	N	P	K	Ca	Mg	Other	Reference
Southeast USA	Pinus virginiana			0.10	0.32	0.55	0.08	Lignin	33.6	Sharpe et al. 1980
Southeast USA	Platanus occid.			0.12	1.65	2.67	0.38	Lignin	18.2	Sharpe et al. 1980
New York, USA	Populus trem.					2.21				Chandler, 1944
Utah, USA	Populus trem. June 9 July 20 Sept 7			.36 .22 .21	1.39 1.18 .99	.59 1.47 2.32	.05 .11 .16	Na	.04 .05 .08	Tev, 1970
Maine, USA	Populus trem.		Branches Stem Stump+roots	.57 .34 .29	.04 .03 .11	.20 .29 .39	1.18 1.33 1.16	.09 .08 .14		Young, 1971
USSR	Populus trem.		Leaves Stem Roots	2.49 .27 .38	.25 .04 .11	1.42 .12 .36	1.69 .40 .87	.26 .04 .08	S .03 .06	Remezov et al. 1959
New Hampshire, USA	Prunus pens.		Leaves Twigs Branches Bark Light wood Roots	2.73 .65 .30 .76 .24 .35	.24 .10 .03 .10 .04 .05	1.71 .63 .17 .48 .26 .34	1.02 .49 .41 1.11 .31 .46	.29 .08 .04 .11 .03 .05		Likens & Bormann, 1970
Southeast USA	Prunus serotina			0.32	1.18	1.95	0.48	Lignin	16.1	Sharpe et al. 1980
New York, USA	Prunus serot.					2.14				Chandler, 1944
B.C., Canada	Pseudotsuga	24	3rd yr needles, 3rd whorl from top No alder + Sitka alder + red alder	1.2 1.4 2.4	0.4 0.1 0.1					Reid 1983
California, USA	Pseudotsuga macrocarpa	?	Needles No poll. Low poll. Mod. poll. Heavy poll. Sev. poll.	1.08-1.17 1.06 0.99-1.31 1.17-2.02 1.15-2.12	0.15-0.16 0.15 0.07-0.16 0.07-0.17 0.06-0.10			S S S	0.13 0.12 0.12	Zinke, 1980

Table 12 Nutrient Concentrations - Overstory (% of dry weight)

Location	Species	Age	Component	N	P	K	Ca	Mg	Other	Reference
Oregon, USA	Pseudotsuga	?	Senescent needles	0.50					Lignin 24.1	Cromack et al. 1979
			Twigs (10 mm)	0.15					Cellulose 59.5	
									Lignin 43.4	
			Roots (2-3 mm)	0.28					Cellulose 26.7	
									Lignin 25.7	
									Cellulose 52.6	
Washington & Oregon, USA	Pseudotsuga infertile site	55	3rd yr needles,							Reid 1983
			lower crown							
			No alder	1.0	0.4				S 0.10	
			+ red alder	1.5	0.2				S 0.08	
Montana, USA	Pseudotsuga	55	3rd yr needles,							Stark, 1979
			No alder	1.4	0.2				S 0.07	
			+ red alder	1.5	0.1				S 0.05	
			Wood & bark <15 cm dbh	0.12	0.07	0.10	0.21	0.02	Cu 9.6 ¹	
									Fe 29 ²	
									Mn 93 ³	
									Na 21 ¹	
									Zn 15 ¹	
									Cu 7.7 ³	
									Fe 17 ¹	
									Mn 43 ¹	
									Na 18 ¹	
									Zn 9 ¹	
									Cu 9.3 ¹	
									Fe 26 ¹	
									Mn 71 ¹	
									Na 24 ¹	
									Zn 12 ¹	
Oregon, USA	Pseudotsuga		3rd yr needles							Reid 1983
			lower crown							
			Control	1.3	0.4				S 0.08	
			Thinned	1.4	0.4				S 0.09	
			Thin.+fert.	1.5	0.4				S 0.09	
UK	Pseudotsuga	21	Needles	1.02	.19	.43	1.37	.14	.07	Ovington, 1956a
Oregon & Wash. USA	Pseudotsuga (Av. 10 plots)	2-5	Foliage	1.11	.30	.88	.331	.126	S .19	Krueger, 1967
									Fe 82 ¹	
									Mn 428 ¹	
									Zn 34 ¹	
									Cu 2 ¹	
									B 8 ¹	
									Na+5 ¹	
									C1924 ¹	

Table 12 Nutrient Concentrations - Overstory (% of dry weight)

Location	Species	Age	Component	N	P	K	Ca	Mg	Other	Reference
Colorado, USA	Pseudotsuga	2	Needles	1.28	.23	.72	.10	.08		
B.C., Canada	Pseudotsuga menziesii	13-50	current needles	.88- 1.37	.12- .22	.38- .70	.16- .44	.07- .18	B 5-16', Cl 90-170', Co .10-.45', Cu 2.4-5.6', Fe 39-68', Mn 450-1150', Zn 15-41', Al 200-750', Si 1400-8700', S 1400-2500', Mo .05-.100'	Beaton et al. 1965a & b
California, USA	Pseudotsuga	2	Needles	1.04	.20	.95	.09	.07		
Washington, USA	Pseudotsuga menziesii	28-52								
Upper Pack			Unfert. Live Branches	.301	.054	.242				
			Fert. Live Branches	.371	.057	.291				
			Unfert. Dead Branches	.191	.040	.071				
			Fert. Dead Branches	.228	.031	.122				
			Unfert. Bark	.298	.057	.250				
			Fert. Bark	.336	.061	.313				
			Unfert. Wood	.052	.007	.056				
			Fert. Wood	.054	.006	.056				
			Unfert. Needles	.905	.291	.874				
			Fert. Needles	1.071	.110	.781				
			Unfert. Live Branches	.274	.054	.176				
			Fert. Live Branches	.315	.053	.168				
			Unfert. Dead Branches	.174	.024	.049				
			Fert. Dead Branches	.181	.029	.051				
			Unfert. Bark	.254	.060	.227				
			Fert. Bark	.266	.054	.191				
			Unfert. Wood	.043	.006	.042				
			Fert. Wood	.043	.005	.039				
			Unfert. Needles	.900	.334	.512				
			Fert. Needles	.978	.195	.423				
			Unfert. Live Branch	.299	.053	.220				
			Fert. Live Branch	.311	.052	.243				
			Unfert. Dead Branch	.241	.020	.033				
			Fert. Dead Branch	.295	.032	.069				
			Unfert. Bark	.256	.046	.210				
			Fert. Bark	.283	.045	.213				
			Unfert. Wood	.050	.005	.029				
			Fert. Wood	.054	.006	.028				
			Unfert. Needles	1.010	.341	.884				
			Fert. Needles	1.066	.173	.688				
			Unfert. Live Branch	.363	.047	.256				
			Fert. Live Branch	.382	.061	.154				
			Unfert. Dead Branch	.201	.033	.060				
			Fert. Dead Branch	.234	.039	.025				
			Unfert. Bark	.362	.070	.343				
			Fert. Bark	.512	.092	.298				
			Unfert. Wood	.048	.006	.031				
			Fert. Wood	.049	.006	.034				
Lower Pack										
Matlock										

Heilman & Gesse
1963

Table 12 Nutrient Concentrations - Overstory (% of dry weight)

Location	Species	Age	Component	N	P	K	Ca	Mg	Other	Reference
Whidbey		Unfert. Needles		.973	.269					
		Fert. Needles		1.438	.165					
		Unfert. Live Branch		.305	.053					
		Fert. Live Branch		.392	.051					
		Unfert. Dead Branch		.213	.019					
		Fert. Dead Branch		.268	.041					
		Unfert. Bark		.301	.041					
		Fert. Bark		.337	.044					
		Unfert. Wood		.051	.004					
		Fert. Wood		.051	.004					
New Mexico, USA	Pseudotsuga	Unfert. Needles		1.051	.362					
		Fert. Needles		1.234	.233					
Oregon	Pseudotsuga menziesii	2 Needles		.97	.22	.98	.10	.11		Van den Driessche, 1969
		450 Foliage current old		1.07	.22	.84	.39	.11	Na 130 ¹	Sollins et al., 1980
Washington, USA	Pseudotsuga	Boles, branch, twigs		1.03	.24	.50	.82	.11	Na 110 ¹	
		Roots >5mm.		.056	.008	.022	.091	.012	Na 48 ¹	
		<5mm.		.090	.008	.030	.148	.031	Na 30 ¹	
		Epiphytes		.620	.100	.170	.69	.12	Na 20 ¹	
		1.73		.24	.57	.03	.17	.03		
B.C., Canada	Pseudotsuga	Needles < 1 yr		1.00	.27	.93	.38	.18	Mn .15	Turner & Olson, 1976
		Needles 1 yr		.96	.29	.73	.60	.18		
		Needles 2 yr		.85	.25	.63	.70	.17	.23	
		Needles 3 yr		.79	.28	.52	.90	.13	.26	
B.C., Canada	Pseudotsuga	23 Needles 1-5yrs.		.93	.22	.59	.48	.09	S 3690 ¹	Binkley, 1982
									Na 52 ¹	
B.C., Canada	Pseudotsuga (with Alnus sin)	23 Needles 1-5yrs.		1.10	.12	.55	.42	.07	Mn 729 ¹	
									Zn 20 ¹	
B.C., Canada	Pseudotsuga (with Alnus rubra)	23 Foliage 1-5yrs.		1.41	.09	.51	.52	.09	Fe 143 ¹	
									Cu 2 ¹	
B.C., Canada	Pseudotsuga	23 Foliage 1-5yrs.							S 2120 ¹	
									Na 51 ¹	
B.C., Canada	Pseudotsuga	23 Foliage 1-5yrs.							Mn 429 ¹	
									Zn 11 ¹	
B.C., Canada	Pseudotsuga	23 Foliage 1-5yrs.							Fe 92 ¹	
									Cu 3 ¹	
B.C., Canada	Pseudotsuga	23 Foliage 1-5yrs.							S 2380 ¹	
									Na 53 ¹	
B.C., Canada	Pseudotsuga	23 Foliage 1-5yrs.							Mn 332 ¹	
									Zn 19 ¹	
B.C., Canada	Pseudotsuga	23 Foliage 1-5yrs.							Fe 74 ¹	
									Cu 4 ¹	

Table 12 Nutrient Concentrations - Overstory (% of dry weight)

Location	Species	Age	Component	N	P	K	Ca	Mg	Other	Reference
Montana, USA	Pseudotsuga	2	Needles	1.37	.21	.92	.18	.12		Webber, 1977 ²
B.C., Canada	Pseudotsuga	20	Foliage < 1 yr	1.01	.24	.81	.53	.12		
			1	1.15	.20	.66	.92	.14		
			2	1.05	.21	.60	1.25	.16		
			3	.98	.25	.62	1.38	.15		
			> 4	.87	.25	.63	1.45	.13		
			Live branch	.48	.11	.41	.76	.11		
			Dead branch	.31	.05	.10	.62	.06		
			Wood	.12	.12	.06	.06	.02		
			Bark	.55	.12	.78	.80	.11		
B.C., Canada	Pseudotsuga	2	Needles	1.31	.25	1.03	.13	.08		
Moravia, Czechoslovakia	Quercus		Leaves	3.56	.17	.69	.82	.22	Ash 4.14	Klino, 1975
			Annual shoots	1.71	.10	.35	1.29	.19	Ash 6.11	
			Branches <2cm-Bark	.95	.05	.59	1.97	.14	Ash 5.77	
			-Wood	.49	.06	.22	.26	.05	Ash 1.40	
			Branches 2-5cm							
			Bark	1.08	.09	.39	2.38	.10	Ash 6.11	
			Wood	.51	.08	.29	.39	.05	Ash 1.72	
			Branches >5cm-Bark	.94	.09	.44	3.18	.09	Ash 9.25	
			-Wood	.28	.04	.15	.20	.03	Ash .94	
			Stem - Bark	.71	.03	.14	2.85	.09	Ash 5.96	
			Stem - Wood	.34	.01	.07	.04	.02	Ash .58	
			Underground Parts							
			0-0.1cm	1.48	.09	.47	.53	.39	Ash22.56	
			0.1-1cm Bark	1.01	.36	.39	2.32	.28	Ash 9.90	
			Wood	.60	.15	.20	.43	.15	Ash 2.60	
			1-2cm Bark	1.09	.17	.51	1.16	.23	Ash 8.99	
			Wood	.87	.17	.10	.16	.10	Ash 1.54	
			2-5cm Bark	1.16	.13	.57	1.76	.14	Ash .09	
			Wood	.75	.15	.10	.14	.09	Ash 1.34	
			5-10cm Bark	.83	.12	.76	2.99	.22	Ash14.85	
			Wood	.53	.19	.09	.05	.09	Ash 1.23	
			>10cm Bark	1.61	.19	.51	2.77	.26	Ash12.03	
			Wood	.80	.16	.10	.15	.09	Ash 1.43	
UK	Quercus < 1 cm		Total	.88	.06	.22	.76	.06	Na .19	Sykes & Barr, 1973
	1			.58	.04	.18	.55	.03	.02	
	2			.41	.02	.13	.56	.03	<.003	
	3			.36	.02	.13	.68	.02	<.003	
	4			.31	.02	.09	.51	.02	<.004	
	6			.28	.01	.09	.65	.02	<.003	
	8			.23	.01	.09	.48	.02	.003	
	10			.19	.01	.08	.58	.02	.003	
	12			.19	.01	.09	.49	.01	<.003	
	> 12			.21	.01	.13	.46	.01	<.003	

Table 12 Nutrient Concentrations - Overstory (% of dry weight)

Location	Species	Age	Component	N	P	K	Ca	Mg	Other	Reference
Korea	Quercus acutif.	12	Leaves	0.78	0.12	0.75				Mun et al. 1977
			Branches	0.34	0.03	0.12				
			Trunks	0.24	0.02	0.06				
			Roots	0.41	0.04	0.41				
New York, USA	Quercus alba						1.36			Chandler, 1944
New York, USA	Quercus alba		Stem heart	.18	.005	.07	.10	.01	S	Woodwell et al. 1975
			Stem sap.	.15	.02	.12	.08	.02		
			Stem bark	.41	.05	.18	2.51	.05		
			Inner bark		.05	.24	2.81	.04		
			Outer bark		.04	.11	3.56	.07		
			Live branch	.28	.07	.24	.57	.06		
			Dead branch	.43	.02	.02	.34	.01		
			Twigs	.56	.08	.33	.64	.08		
			Leaves	.79	.06	.70	.49	.09		
			Fruits	.64	.10	.78	.18	.06		
			Flowers	2.63	.24	1.78	.16	.24		
			Root crown	.16	.02	.16	.07	.01		
			Root wood		.23	.18	.13	.11		
			Root bark		.06	.24	1.63	.11		
			Small roots		.17	.24	.34	.10		
Southeast USA	Quercus alba		Leaves	1.885	0.10	0.38	0.88	0.14	Lignin 17.2	Sharpe et al. 1980
USA	Quercus alba				216	.572	1.181	.062	Cu 10.3, Fe 92, Mn 4075, Na 313, Zn 22.2	Stark, 1973
New York, USA	Quercus boreal.		Stem heart	.14	.002	.06	.05	.005	S	Chandler, 1944
New York, USA	Quercus cocc.		Stem sap.	.10	.003	.14	.05	.016		Woodwell et al. 1975
			Stem bark	.32	.04	.15	.13	.04		
			Inner bark		.06	.26	.19	.04		
			Outer bark		.03	.06	.15	.04		
			Live branches	.31	.03	.21	.52	.04		
			Dead branches	.31	.007	.03	.20	.01		
			Twigs	.47	.07	.25	.51	.28		
			Leaves	.79	.05	.51	.39	.11		
			Fruits	.50	.09	.66	.66	.08		
			Flowers	1.45	.24	1.97	.55	.27		
			Root crown	.22	.03	.12	.07	.01		
			Root wood		.04	.24	.05	.06		
			Root bark		.03	.23	.88	.06		
			Small roots		.11	.27	.26	.05		

Table 12 Nutrient Concentrations - Overstory (% of dry weight)

Location	Species	Age	Component	N	P	K	Ca	Mg	Other	Reference
Southeast USA	<i>Quercus coccinea</i>			0.10	0.38	0.88	0.14	Lignin 16.7		Sharpe et al. 1980
Southeast USA	<i>Quercus falcata</i>			0.10	0.38	0.88	0.14	Lignin 16.7		Sharpe et al. 1980
New York, USA	<i>Quercus ilic.</i>		Stem sap	.12	.02	.13	.05	.02	.03	Woodwell et al. 1975
			Stem bark	.56	.06	.20	1.21	.05	.07	
			Live branch	.40	.04	.17	.51	.03	.04	
			Dead branch	.39	.01	.02	.22	.007	.05	
			Twigs	.77	.09	.27	.58	.03	.06	
			Leaves	1.40	.09	.42	.5	.16	.26	
			Root crown	.29	.08	.20	.09	.08	.02	
			Small roots	.20	.22	.22	.29	.08	.06	
New York, USA	<i>Quercus mont.</i>						1.20			Chandler, 1944
UK	<i>Quercus pet.</i>	20	Leaves	2.91	.16	.74	.49	.21	.02	Ovington, 1956a
Southeast USA	<i>Quercus prinus</i>			0.16	1.02	1.00	0.14	Lignin 25.5		Sharpe et al. 1980
USA	<i>Quercus prinus</i>		Leaves	.887	.358	.662	1.562	.487	Cu 14.6, Fe 1250, Mn 329, Na 332, Zn 55,	Stark, 1973
UK	<i>Quercus robur</i>	46	Leaves	2.91	.25	1.20	1.03	.22	.02	Ovington, 1956a
Belgium	<i>Quercus robur</i>	89	Twigs - 1 yr	1.3	.10	.36	1.4	.15	S	Duvigneaud & Denaeyer-de Smet, 1970
			2	1.0	.08	.29	1.3	.16		
			3	1.0	.08	.26	1.5	.18		
			Branch 1-3 cm	.50	.05	.14	.21	.05		
			Branch-bark	.74	.06	.27	2.4	.27		
			Branch 5-7 cm	.28	.03	.21	.11	.05		
			Branch-bark	.85	.04	.26	2.4	.32		
			Branch 10-15 cm	.13	.003	.17	.07	.15		
			sapwood	.16	.02	.17	.09	.03		
			bark	.57	.03	.20	2.9	.37		
			Branch 20-25 cm	.14	.004	.10	.10	.02		
			sapwood	.24	.02	.19	.12	.04		
			bark	.41	.04	.26	3.2	.31		
			Stem heart	.15	.002	.08	.09	.009	.03	
			sapwood	.19	.02	.16	.13	.08	.01	
			bark	.40	.02	.23	3.4	.30	.06	
			Roots 1-3	.45	.02	.21	.10	.03		
			bark	.52	.03	.39	2.1	.07		
			Roots 5-7	.24	.02	.19	.06	.02		
			bark	.83	.02	.40	2.1	.10		
			Leaves	2.4	.15	1.0	1.0	.14		

Table 12 Nutrient Concentrations - Overstory (% of dry weight)

Location	Species	Age	Component	N	P	K	Ca	Mg	Other	Reference
UK	Quercus rubra	20	Leaves	2.87	.17	.79	.67	.20	.01	Ovington, 1956a
Southeast USA	Quercus rubra				0.10	0.38	0.88	0.14	Lignin 16.7	Sharpe et al., 1980
USA	Quercus rubra		Leaves	1.731	.131	.825	1.282	.288	Cu 10.2 ¹ Fe 116 ¹ Mn 1575 ¹ Na 375 ¹ Zn 24.8 ¹	Stark, 1973
UK	Quercus sp.	43	Leaves	2.59	.23	1.09	.74	.14	.02	Ovington, 1956a
UK	Quercus sp.		Leaves		.19	.92	.83	.20	.03	Ovington, 1956a
New York, USA	Quercus spp. May 27 June 26 July 26 Aug 26 Sept 25		Leaves	3.75 2.76 2.63 2.47 2.40	.34 .17 .15 .15 .15	1.47 1.21 1.04 1.00 1.00	.54 .65 .75 .91 .95			Tryon, 1936
Southeast USA	Quercus stellata				0.10	0.38	0.88	0.14	Lignin 16.7	Sharpe et al., 1980
USA	Quercus velutina		Leaves	2.004	.255	.587	.487	.113	Cu 11.2 ¹ Fe 93 ¹ Mn 3000 ¹ Na 329 ¹ Zn 34.3 ¹	Stark, 1973
Southeast USA	Quercus velutina				0.10	0.38	0.88	0.14	Lignin 16.7	Sharpe et al., 1980
Southeast USA	Rhododendron maxl.				0.03	0.24	1.28	0.19	Lignin 15.7	Sharpe et al., 1980
New York, USA	Robinia pseud.						2.65			Chandler, 1944
Southeast USA	Robinia pseud.				0.35	1.65	3.15	0.35	Lignin 25.1	Sharpe et al., 1980
New York, USA	Thuja occid.						2.48			Chandler, 1944
Montana, USA	Thuja plicata		Wood & bark <15 cm dbh	0.08	0.01	0.03	0.15	0.01	Cu 7.0 ¹ Fe 31 ¹ Mn 5 ¹ Na 30 ¹ Zn 2 ¹	Stark, 1979
			Wood & bark >15 cm dbh	0.09	0.02	0.02	0.10	0.01	Cu 5.2 ¹ Fe 35 ¹ Mn 4 ¹ Na 26 ¹ Zn 3 ¹	

Table 12 Nutrient Concentrations - Overstory (% of dry weight)

Location	Species	Age	Component	N	P	K	Ca	Mg	Other	Reference
UK	<i>Thuja plicata</i>	21	Needles	1.22	.10	.38	1.05	.16	.04	Ovington, 1956a
B.C., Canada	<i>Thuja plicata</i>	58	foliage	.73	.13	.52	1.16	.10	S 700 ¹	Beaton et al., 1965a
Czechoslovakia	<i>Tilia</i>		Leaves	2.76	.34	1.47	1.75	.24	Ash 9.51	Klino, 1975
			Annual shoots	1.82	.20	.60	1.97	.25	Ash 8.22	
			Branches <2cm-Bark	1.19	.10	.42	1.85	.11	Ash 5.67	
			-Wood	.94	.10	.29	.30	.07	Ash 1.96	
			Branches 2-5cm							
			-Bark	1.44	.11	.40	1.51	.11	Ash 5.02	
			-Wood	1.15	.06	.22	.24	.06	Ash 1.42	
			Branches >5cm-Bark	1.11	.11	.43	1.53	.12	Ash 5.51	
			-Wood	.67	.04	.21	.30	.03	Ash 1.14	
			Stem - Bark	.82	.08	.49	1.25	.14	Ash 3.49	
			Stem - Wood	.30	.01	.11	.10	.02	Ash .84	
			Underground parts							
			0-0.1cm	1.31	.12	.53	.24	.36	Ash23.46	
			0.1-1cm Bark	1.91	.20	.51	1.41	.25		
			Wood	.63	.12	.40	.22	.24	Ash 1.93	
			1-2cm Bark	1.27	.19	.52	1.96	.24	Ash11.81	
			Wood	.49	.09	.27	.16	.08	Ash 1.35	
			2-5cm Bark	1.07	.11	.52	4.17	.25	Ash14.21	
			Wood	.91	.09	.19	.20	.10	Ash 1.49	
			5-10cm Bark	.84	.14	.61	3.38	.28	Ash20.90	
			Wood	.43	.06	.10	.17	.07	Ash .85	
			>10cm Bark	.79	.12	.70	2.20	.23	Ash15.76	
			Wood	.62	.07	.10	.16	.10	Ash 1.04	
New York, USA	<i>Tilia amer.</i>						2.81			Chandler, 1944
USSR	<i>Tilia cord.</i>		Leaves	2.81	.21	1.72	1.48	.29	S .21	Remezov et al., 1959 ¹
			Branches	.31	.03	.24	.41	.04	S .08	
			Roots	.64	.07	.38	.84	.14	S .08	
Maine, USA	<i>Tsuga</i>		Branches	.39	.10	.19	1.39	.08		Young, 1971
			Stem	.24	.05	.12	.83	.04		
			Stump+roots	.31	.06	.11	.54	.04		
New York, USA	<i>Tsuga canadensis</i>						.80			Chandler, 1944
USA	<i>Tsuga canadensis</i>		needles	1.414	.197	.700	.562	.100	Cu 9.8 ¹ Fe 340 ¹ Mn 2625 ¹ Na 313 ¹ Zn 62.5 ¹	Stark, 1973

Table 12 Nutrient Concentrations - Overstory (% of dry weight)

Location	Species	Age	Component	N	P	K	Ca	Mg	Other	Reference
Montana, USA	Tsuga heter.		Wood & bark <15 cm dbh	0.07	0.08	0.04	0.09	0.02	Cu 6.6 ¹ Fe 29 ¹ Mn 190 ¹ Na 33 ¹ Zn 6 ¹	Stark, 1979
			Wood & bark 15-30 cm dbh	0.07	0.05	0.04	0.08	0.02	Cu 6.3 ¹ Fe 36 ¹ Mn 153 ¹ Na 36 ¹ Zn 6 ¹	
B.C., Canada	Tsuga heter.	8-185	current needles	.86- 1.17	.11- .19	.28- .57	.18- .27	.08- .12	S 1000-1500 ¹ B 5-17 ¹ Cl 75-160 ¹ Co .05-17 ¹ Cu 3.9-4.2 ¹ Fe 40-68 ¹ Mn 1580-2000 ¹ Mo <.05-.05 ¹ Zn 3-14 ¹ Al 465-790 ¹ Si <467 ¹	Beaton et al., 1965a & b
Haney, B.C. Canada	Tsuga heter.	climax old growth	Foliage & Twigs	40.0	30.8	12.2	22.4			Kimmins & Krumlik, 1976
Oregon	Tsuga mert.		Leaves	.16	.64	.33	.08		S .06 B 29 ¹ Zn 15 ¹ Fe 60 ¹ Mn 1780 ¹	Will & Youngberg, 1979
B.C., Canada	Tsuga mert.	300+	Wood Bark Large branch Small branch Twigs Foliage	.05 .18 .12 .17 .38 .85	.02 .06 .03 .04 .06 .11	.07 .09 .07 .09 .16 .30	.07 .31 .16 .18 .18 .31	.02 .02 .02 .03 .04 .08		Krumlik, 1978
New York, USA	Ulmus amer.		Leaves	1.47	.11	1.08	.30	.34	S .37	Chandler, 1944
USSR	Ulmus laevis		Branches Stem	.37 .22	.04 .02	.68 .62	1.19 .65	.07 .06	S .08 S .04	Mina, 1955 ¹

¹Cited in Rodin and Bazilevich, 1967.²Maximum values³parts per million

Table 13 Nutrient Concentrations - Understory

Location	Species	Component	N	P	K	Ca	Mg	Other	Reference	
Australia	Acacia spp.	Stemwood	.16	.016	.04	.04	.02	Na	.02	
		Stembark	.62	.021	.20	.73	.11		.02	
		Branches	.23	.011	.07	.07	.03		.01	
		Leaves	3.37	.170	.54	.37	.14		.01	
		Leaves	2.08	.111	.53	.23	.17		.05	
USA	Adiantum Amphicarpum Collinsonia Comptonia Lindera	Leaves	.83	.14	1.54	.98	.28	S	.24	
		Leaves	1.74	.19	1.35	1.91	.45	S	.57	
		Leaves	.73	.20	1.03	.85	1.27	S	.60	
		Leaves	2.04	.18	.72	.54	.18	S	.23	
		Leaves	1.85	.23	1.55	1.56	.49	S	.32	
Oregon, USA	Arctostaphylos patula	Foliage		.18	1.00	.40	.23	S	.06	
							B	13		
							Zn	45		
							Fe	30		
							Mn	40		
USSR	Asarum euro. Aegopodium Asperula odor.	Leaves	3.18	.24	5.82	2.17	.46	S	.12	
		Leaves+stem	1.51	.40	6.23	1.09	.32	S	.15	
		Leaves+stem	1.91	.24	4.47	2.20	.32	S	.15	
	New Hampshire, USA	Siccama et al. 1970	Above ground	2.53	.18	3.04	.81	.38	S	.19
				2.82	.18	2.03	.21	.24		.22
				2.38	.17	2.78	.54	.42		.31
				2.25	.15	2.81	.61	.43		.33
				2.47	.20	2.58	.37	.43		.22
				2.01	.10	1.41	.06	.12		.17
				2.41	.18	2.88	.29	.13		.21
				2.32	.22	1.71	.80	.28		.19
					.21	1.78	.92	.24		.22
				2.14	.19	2.92	.67	.30		.18
			2.84	.22	1.90	.18	.14	B	.29	
			2.86	.15	3.23	.26	.15		.22	
			2.29	.16	4.47	1.10	.35		.14	
			1.79	.25	1.35	3.09	.45		.22	
			2.83	.20	2.14	1.70	.27		.31	
			2.40	.22	4.99	.86	.30		.17	
			2.30	.13	2.24	.46	.34		.22	
				.11	1.15	1.14	.35		.15	
			.25	.25	2.92	.60	.40		.33	
			.32	.32	5.45	.52	.14			

Table 13 Nutrient Concentrations - Understorey

Location	Species	Component	N	P	K	Ca	Mg	Other	Reference
USSR	<i>Cladonia alpe.</i> <i>Parmelia saxa.</i>	Entire Entire	.79	.06 .05	.37 .16	.08 .28	.04 .11	S .05 S .10	Rozhnova, 1962
Alberta, Canada	<i>Epilobium</i>	Leaves Stems	3.22 .67	.21 .12	2.41 1.68	.80 .26	.55 .17		Krauler, 1976
Washington USA	<i>Gaultheria</i> shailon	current	1.15	.20	1.11	.49	.20	Mn 943 Fe 268 Zn 20 Na 51 Ash 2.77 Mn 3212 Fe 259 Zn 24 Na 41 Ash 4.89 Mn 974 Fe 158 Zn 45 Na 20 Ash 8.50 Mn 5662 Fe 142 Zn 23 Na 21 Ash 6.30 Mn 493 Fe 53 Zn 54 Na 14 Ash 2.27 Mn 1240 Fe 180 Zn 65 Na 9 Ash 9.17 Mn 832 Fe 148 Zn 38 Na 20 Ash 8.41 Mn 1590 Fe 300 Zn 21 Na 48 Ash 3.30 Mn 3820 Fe 320 Zn 23 Na 52 Ash 4.60 Mn 450 Fe 310 Zn 23 Na 47 Ash 9.11	Turner, Long & Backiel 1978
stand age 42 yrs.		older	.85	.08	.65	1.62	.28		
	<i>Pteridium aquilinum</i>		1.90	.27	.74	.73	.22		
	<i>Vaccinium parv.</i>		1.62	.14	1.12	1.33	.19		
	<i>Berberis nervosa</i>		1.10	.11	.85	.31	.10		
	<i>Acer circnatum</i>		2.27	.28	1.15	1.17	.35		
	<i>Linnea borealis</i>		1.42	.25	1.70	1.71	.29		
stand age 95	<i>Gaultheria</i> shailon	current	.099	.13	.97	.49	.20		
		older	.091	.09	.63	.98	.23		
	<i>Linnea borealis</i>		1.00	.22	1.72	1.17	.28		

Table 13 Nutrient Concentrations - Understory

Location	Species	Component	N	P	K	Ca	Mg	Other	Reference
	Vacc. parv.		1.95	.19	1.10	1.25	.23	Mn 2320, Fe 420, Zn 19, Na 47, Ash 6.10 Mn 1090, Fe 870, Zn 29, Na 46, Ash 2.30 Mn 900, Fe 840, Zn 30, Na 47, Ash 1.72 Mn 2002, Fe 720, Zn 27, Na 45, Ash 3.27 Mn 2250, Fe 800, Zn 45, Na 56, Ash 2.87 Mn 1820e, Fe 530, Zn 45, Na 55, Ash 4.20	
	Mnium spinulosum		.54	.19	.44	.24	.07		
	Mnium insignia		.61	.08	.40	.20	.07		
	Rhytidadelphus loreus		.56	.15	.67	.32	.09		
	Plageocheilium undulatum		.85	.19	.65	.39	.16		
	Eurynchium oregonum		.53	.21	.56	.41	.10		
New York, USA	Gaylussacia	Stem sap. Stem bark Live branch Dead branch Twigs Leaves Fruit Flowers Roots Rhizome Stem sap. Stem bark Stem wood Live branch Dead branch Twigs Leaves Fruit Flowers Small roots Tap root Rhizome Stem sap. Wood+bark Live branch	.25 .47 .46 .48 .71 .75 .60 1.73 .40 .32 .26 .55 .47 .53 .63 .60 1.73 .43 .54	.03 .04 .04 .01 .08 .08 .10 .24 .05 .06 .05 .06 .08 .02 .10 .08 .24 .06 .07 .06 .10 .08 .08 .08	.13 .15 .14 .01 .25 .67 .72 1.61 .15 .20 .25 .27 .24 .03 .25 .47 1.61 .13 .13 .16 .18 .18	.06 .23 .23 .10 .79 .84 .42 .25 .21 .21 .07 .56 .59 .26 .80 .88 .72 1.61 .09 .13 .12 .33 .20 .04 .04 .06 .33	.04 .05 .05 .06 .13 .32 .07 .20 .07 .05 .04 .13 .07 .09 .13 .33 .20 .04 .04 .06 .06 .06 .06	S S	Woodwell et al. 1975
	Vaccinium vac.								
	Vaccinium ang.								

Table 13 Nutrient Concentrations - Understory

Location	Species	Component	N	P	K	Ca	Mg	Other	Reference
N. Stradbroke Island, Australia	<i>Hibbertia vestita</i>	Current leaves	2	.08	.9	.97	.44	Na .1 S .152	Westman & Rogers 1977
		Older leaves	1.30	.04	1.40	1.300	.400	Na .26	
		Current leaves	.6	.06	.5	.14	.07	Na .192 S 1 2.505	
		Current leaves	.3	.02	.4	.22	.07	Cu .0015 Zn .0069	
		Current leaves	1.6	.07	.5	.58	.15	Pb .0005	
	<i>Imperata cylindrica</i> <i>Lepidosperma laterale</i> <i>Leucopogon margarodes</i>	Current leaves	.93	.043	.44	.550	.080	Na .1	
		Current leaves	1.8	.06	.7	1.07	.11	Na .08	
		Current leaves	1.2	.04	.6	.39	.13	Na .12	
		Current leaves	.95	.023	.78	.620	.194	Na .11	
	<i>Lomandra longifolia</i> <i>Monotoca scoparia</i>	Current leaves	.31	.005	.21	.350	.039	Na .200	
		Current leaves	1.3	.08	.5	.28	.16	Na .096	
		Current leaves	.96	.095	.50	.225	.090	Na .13	
	<i>Parsoonia virgata</i> <i>Petrophile sessilis</i>	Current leaves	.8	.07	.3	.16	.15	Na .12	
		Current leaves	.82	.030	.53	.380	.172	Na .04	
		Current leaves	.30	.034	.25	.750	.020	Na .07	
	<i>Pteridium esculentum</i> <i>Pultenaea villosa</i> <i>Tristania conferta</i>	Current leaves	1.7	.10	.9	.12	.13	Na .13	
		Current leaves	2.6	.08	.6	.55	.28	Na .17	
		Current leaves	1.6	.08	.8	.73	.25	Na .1	
		Current leaves	1.7	.07	.7	.87	.29	Na .09	
'Alaska, USA	<i>Hylacomium splendens</i> <i>Pleurozium schreberi</i>	Green	0.59-0.83					S .14	Weber and Van Cleve, 1981
		Brown	0.52-0.72						
		Green	0.57-0.76						
		Green	0.54-0.58						

Table 13 Nutrient Concentrations - Understory

186

Location	Species	Component	N	P	K	Ca	Mg	Other	Reference
Sweden	<i>Hylocomium sple.</i>	Entire	.77	.17	.47	.18		Na .01	Tamm, 1954
Germany	<i>Hypnum shreb.</i>	Entire	1.18	.23	.60	.59	.17	S .06 Na .07	Wolff, 1871 ¹
Florida, USA	<i>Ilex glabra</i>	Wood Foliage	0.31 0.95	0.03 0.05	0.09 0.21	0.48 0.57	0.11 0.20		West et al., 1981 (prelim. data)
USSR	<i>Juniperus com.</i>	Needles < 1 yr	1.34	.18	.62	1.02	.21	Na .02	Rudneva et al. ¹
		> 2 yr	1.11	.12	.46	1.42	.20	.01	
	<i>Vaccinium vitis</i>	Leaves < 1 yr	1.21	.14	.61	.56	.14	.01	
		> 1 yr	.90	.10	.42	.36	.10	.02	
Oregon, USA	Mosses+Lichens	Entire-min max	.61 1.84	.07 .15	.13 .47	.21 1.56	.05 .13		Abee, 1973
Florida, USA	<i>Myrica cerifera</i>	Wood Foliage	0.55 1.46	0.01 0.03	0.08 0.22	0.55 0.82	0.08 0.19		West et al., 1981 (prelim. data)
USA	<i>Osmunda cin.</i>	Leaves	2.18	.23	3.88	1.22	.59		Scott, 1955
USSR	<i>Oxalis acet.</i>	Leaves	2.61	.38	2.98	1.30	.20	S .16	Remezov et al., 1959 ¹
USSR	<i>Peltigera apht.</i>	Entire	2.87	.10	.38	.32	.10	S .03	Verdokimova, 1957 ¹
Ontario	<i>Pinus banksiana</i> 65	Ground veg.	4	<1	2	1	<1	Biomass 310	Morrison & Foster 1979
Florida, USA	<i>Pinus elliotii</i>	Bole Branches Foliage	0.11 0.23 0.80	0.01 0.02 0.03	0.02 0.06 0.24	0.17 0.29 0.24	0.02 0.04 0.12		West et al., 1981 (prelim. data)
Belgium	<i>Polygonatum</i>	Leaves	3.0	.21	3.8	1.4	.37		Duvigneaud & Denaeyer-de Smet, 1967
	<i>Arum macu.</i>	Leaves	3.9	.40	3.6	.62	.21		
	<i>Ornithogalum</i>	Leaves	5.3	.49	3.5	.40	.20		
	<i>Allium urs.</i>	Leaves	4.6	.37	3.4	.70	.17		
	<i>Narcissus psu.</i>	Leaves	4.3	.30	2.8	.36	.18		
	<i>Pulmonaria</i>	Leaves	2.2	.17	6.6	2.4	.17		
	<i>Ficaria ran.</i>	Leaves	2.1	.40	6.6	1.9	.20		
	<i>Lamium gal.</i>	Leaves	2.5	.25	5.9	1.4	.36		
	<i>Primula elat.</i>	Leaves	2.5	.19	4.9	.64	.30		
	<i>Viola reit.</i>	Leaves	2.1	.28	4.4	1.1	.50		
	<i>Geum rivale</i>	Leaves	3.0	.20	3.5	1.5	.50		
	<i>Anemone nem.</i>	Leaves	2.8	.18	3.0	2.2	.38		
	<i>Circea lut.</i>	Leaves	2.6	.16	3.0	2.0	.50		
	<i>Hedera helix</i>	Leaves	1.7	.10	1.1	1.2	.24		
	<i>Rosa arve.</i>	Leaves	1.8	.13	1.9	1.8	.35		
		Stems	.8	.10	1.2	.9	.30		
	<i>Rubus sp.</i>	Leaves	2.5	.15	1.5	1.1	.43		
		Stems	1.0	.10	1.0	.6	.40		

Table 13 Nutrient Concentrations - Understory

Location	Species	Component	N	P	K	Ca	Mg	Other	Reference
B.C., Canada	Pseudotsuga-seed dead	Total	.33	.04	.16	.43	.07		Webber, 1977
			.26	.03	.12	.34	.04		
	Thuja - seedling		.44	.04	.22	.74	.05		
			.60	.04	.40	.91	.16		
	Gaultheria - live dead		.37	.03	.05	.66	.06		
			.93	.11	.77	.89	.11		
Oregon, USA	Berberis nerv.		.51	.11	.31	.82	.11		Will & Youngberg 1979
			.25	.15	1.38	.58	.21		
	Rosa spp.							B	
								Zn	
	Polystichum mun.							Fe	
								Mn	
	Purshia tridentata							B	
								Zn	
	Foliage							Fe	
								Mn	
Germany	Sphagnum cusp.							B	Wolff, 1871
								Zn	
	Sphagnum sp.							Fe	
								Mn	
	Entire							B	
								Zn	
USSR	Sphagnum fusc.							Fe	Bazilevich
								Mn	
	Sphagnum recu.							B	
								Zn	
	Sphagnum medi.							Fe	
								Mn	
Oregon, USA	Stokesiella oreg.							S	Binkley & Graham 1981
								Na	
	1-yr.							S	
								Na	
	2-yr.							S	
								Na	
	Green							S	
								Na	
	Yellow							S	
								Na	
Oregon, USA	Brown							S	Binkley & Graham 1981
								Na	
	Hylacomium splendens							S	
								Na	
	S							S	
								Na	

Table 13 Nutrient Concentrations - Understory

Location	Species	Component	N	P	K	Ca	Mg	Other	Reference
B.C., Canada	Tsuga, Abies	300							
		Hygric							
		Shrub & herb	3.71	0.36	4.35	0.70	0.29	Mn 602 ppm Zn 52 ppm Cu 15 ppm Mn 1084 ppm Zn 70 ppm Cu 23 ppm	
		Bryophyte	2.33	0.17	1.32	0.55	0.14		
		Mesic							
		Shrub & herb	2.54	0.25	3.46	0.51	0.30	Mn 418 ppm Zn 41 ppm Cu 9 ppm Mn 532 ppm Zn 49 ppm Cu 27 ppm	
		Bryophyte	2.48	0.20	0.91	0.28	0.08		
		Xeric							
		Shrub & herb	2.08	0.18	1.22	0.37	0.24	Mn 272 ppm Zn 42 ppm Cu 11 ppm Mn 226 ppm Zn 36 ppm Cu 24 ppm	West et al., 1981 (prelim. data)
		Bryophyte	2.26	0.20	1.15	0.27	0.09		
Florida, USA	Vaccinium fuscatum	Wood	0.37	0.03	0.13	0.60	0.06		
		Foliage	1.09	0.05	0.18	0.85	0.19		
USSR	Vaccinium myrt.	Leaves	1.46	.12	.45	.45	.13	S .07	Marchenko-Karlov, 1962
	Vaccinium vitis	Leaves	1.27	.11	.47	.48	.18	S .06	
	Vaccinium ulig.	Leaves	1.28	.13	.38	.24	.13	S .06	
	Empetrum nigr.	Leaves	1.26	.10	.39	.39	.16	S .06	

Cited in Rodin and Bazilevich, 1967

Maximum values

parts per million

Table 14 Annual Outputs

Location	Dom. Veg.	Output type	N	kg/ha/yr P	K	Ca	Mg	Na	Others	Reference	
Storsjön, Sweden	Mixed conifer	Stream-water	2.3	.02	4.0	12.2	8.7	37.5	S04-S 25.3	W. Dickson, cited in Likens et al. 1977	
B.C., Canada	Mixed conifer	Stream-water	NH ₄ .54 NO ₃ .82	.73	2.6	42.	8.8	26.	S04 Cl SiO ₂ 92.	Zeman, 1973	
Hubbard Brook, N.E. U.S.	Mixed hardwood	Stream-water	4.0	.020	2.4	13.9	3.3	7.4	Al H SO ₄ 52.8 Cl SiO ₂ 37.7 HCO ₃ 7.77	Likens et al. 1977	
Tanghannock Creek, N.E. U.S.	Mixed hardwoods	Stream-water	5.6	.20	5.6	182.	34.8	18.9		Likens 1974	
New Hampshire, USA	Mixed Hardwoods	Stream-water	NH ₄ -N-6.6 NH ₄ -N-0.4	-	-	3.4	23.0	3.4	S04-S-16.1	Martin, 1979	
Silverstream, New Zealand	Nothofagus	Stream-water	1.8	.03	13.	26.	13.	62.	S04-S 13.	Miller 1963	
Blue Range Catchment Australia	Pinus	Stream-water		.42		5.5	8.7	16.2		P.M. Hallam, cited in Likens et al. 1977	
New Zealand	Pinus radiata	Leaching	n.d. ¹	.01	4.2	5.7	1.6	12.5	Si Cl	Knight & Will 1977	
S. Carolina, USA	Pinus taeda	Stream-water	(NH ₄ -N) 0.04- 0.08 (NO ₃ -N) 0.03- 0.07	0.004- 0.04- 0.026	0.7- 0.4- 1.4	0.4- 0.6	0.3- 1.3	0.5-		West et al 1981 (prelim. data)	
Velen, Sweden	Pinus, Picea	Stream-water	0.4		2.5	11.1	3.2	9.2	S04-S 9.4	Eriksson 1974	
ELA, Ontario, Canada	Pinus, Picea		0.9	.05	1.2	6.0	2.4	3.7	S04-S 3.2	Schindler et al. 1976	
Finland	Pinus, Picea		2.	.3	4.6	12.	4.	6.	S04-S 4.7	Viro 1953	
Washington, USA	Pinus, Pseudo.	Stream-water	1.3	.13	4.4	20.8	4.6	11.4		Tiedeman et al. 1978	
Michigan, USA	Populus (good site) Clearcut plot (good site) Populus tremuloides (med. site) Clearcut plot (med. site) Populus	Leaching Leaching Leaching	NH ₄ -N 0.1 NO ₃ -N 0.3 NH ₄ -N 0.1 NO ₃ -N 0.2 NH ₄ -N 0.2 NO ₃ -N 0.1 NH ₄ -N 0.2 NH ₄ -N 0.1	.3 .5 .3	7.6 9.6 7.4	38.8 65.2 28.6	17.7 26.6 7.0	6.7 15.3 10.6	Fe Fe Fe	0.3 0.4 0.2	Richardson & Lund, 1975
		Leaching		.4	11.2	36.2	6.6	14.2	Fe	0.4	
		Leaching		.3	5.3	19.4	3.9	11.2	Fe	0.2	

Table 14 Annual Outputs

Location	Dom. Veg.	Output type	N	kg/ha/yr P	K	Ca	Mg	Na	Others	Reference
Tesuque Watersheds, S.W. U.S.	tremuloides (poor site)	Leaching	NO ₃ -N 0.1 NH ₄ -N 0.1 NO ₃ -N 0.1	.3	7.6	19.8	4.9	12.0	Fe 0.2	Gosz 1977, cited in Likens et al. 1977
	Clearcut plot (poor site)									
	Populus, Mixed Conifer, Pinus, Juniperus	Stream-water			3.2 2.1 1.2	13.1 10.1 22.3	4.2 3.4 10.8	10.0 6.5 4.9		
Washington, USA	Pseudotsuga									Bigger and Cole 1983
	High productivity									
	Control		0.02	0.04	5	50	21	5	SO ₄ 7.5	
	Bole harvest		0.22	0.02	8	75	6	17	SO ₄ 6.2	
	Whole tree		0.14	0.30	8	82	20	10	SO ₄ 6.7	
	Complete		0.04	0.14	14	60	16	12	SO ₄ 3.2	
Oregon, USA	Low productivity									Sollins et al. 1980
	Control		0.08	0.07	11	34	15	14	SO ₄ 24	
	Bole harvest		0.33	0.02	4	22	6	14	SO ₄ 8	
	Whole tree		3.26	0.01	8	38	7	10	SO ₄ 7	
	Complete		4.66	0.02	14	32	10	2	SO ₄ 10	
	Pseudotsuga menziesii	Soil leaching	1.5	.8	9.5	123	9		53	
Cascade Mtns. W. U.S.	Pseudotsuga	Stream-water	1.2	.51						Fredriksen 1975
Cedar River, N.W. U.S.	Pseudotsuga	Soil Leaching	0.6	.02	1.0	4.5				Cole et al. 1967
Andrews Forest, Ore., U.S.	Pseudotsuga	Stream-water	.38	.52	2.25	50.32				Fredriksen 1975
Walker Branch, S.E. U.S.	Quercus, Carya	Stream-water	1.8	.02	6.8	148.	77.1	4.5	SO ₄ -S 11.3	G. Henderson, cited in Likens et al. 1977
Coveata, N.C. U.S.	Quercus, Carya	Stream-water	.08	.02	5.6	8.7	4.3	12.4	SO ₄ 9.1 Cl 8.9 SiO ₂ 97.3	Swank & Douglas 1977
		Denitrifi- cation	18.							Todd et al. 1975
Long Island, NY, N.E. U.S.	Quercus, Pinus	Stream-water			3.9	9.6	7.3	23.		Woodwell and Whittaker 1967
S.E. U.S.	Quercus, Pinus	Stream-water	1.		6.	19.	6.	26.	SO ₄ -S 7.	Gambell & Fisher 1966

Table 14 Annual Outputs

Location	Dom. Veg.	Output type	N (NO ₃ +NH ₄)-N	P	kg/ha/yr	K	Ca	Mg	Na	Others	Reference
Harney, B.C., Canada	Tsuga, Pseudo., Thuja	Stream-water	1.0	.0	1.6	16.9	3.4	10.8	10.8	10.8 SO ₄ -S 7.3	Feller & Kimmins 1979

1 none detected

Table 15 Outputs - Denitrification

Location	Dominant Veg.	Age	Source	Amt (kg/ha/yr)	Reference
Finland (all potentials)	Calluna pine		Organic layers (0-5 cm)	3.5x10 ⁻¹ nmoles g ⁻¹ hr ⁻¹	Muller & Sundman, 1980
			A layer (5-7)	4.0x10 ⁻¹ nmoles g ⁻¹ hr ⁻¹	
			B layer (7-30)	18.54 nmoles g ⁻¹ hr ⁻¹	
	Calluna spruce		Organic layers (0-5)	7.56x10 ⁻¹	
	Vaccinium pine		B layer (5-30)	8.96	
			Organic layer (0-3)	1.6x10 ⁻¹	
			A (3-5)	6.0x10 ⁻¹	
			B (5-30)	15.0	
	Vaccinium spruce		Organic layer (0-5)	3.5x10 ⁻¹	
	Mrytilus spruce		B layer (5-30)	20.6	
			Organic layer (0-10)	2.0x10 ⁻¹	Melillo et al. 1983
			A (10-15)	1.4	
			B (15-30)	10.6	
			Organic 0-5	10.6	
			A 5-40	12.6	
			Organic 0-5	6.6	
			A 5-30	8.1	
	Oxalis-Mrytilus Spruce		Organic 0-10	12.2 nmoles g ⁻¹ hr ⁻¹	
	Melica lathyrus		A 10-20	18.0	
	Deciduous forest		Organic 0-20	11.3	
	Oxalis Malanthemum		Organic 0-5	25.5	Hendrickson, 1981
	Deciduous forest		A 10-20 cm	12.8	
New Hampshire, USA	Hardwoods	2	Soil+forest floor Aerobic scenario	0.4	
			Anaerobic scenario	52	
		50	Soil+forest floor Aerobic scenario	1.4	
			Anaerobic scenario	9.0	
			Total	8 kg N ha ⁻¹ yr ⁻¹	
			Total	24-36	
			Total	295	
Georgia	Lowland pine Deciduous forests				Melillo et al. 1983
	Downslope from cornfields				
	Downslope from hogpens				
NE USA	Mix dec. 2 year old clearcut		FF+M5 (0-20 cm) anaerobic	51.6 kg N ha ⁻¹ yr ⁻¹	
			aerobic	0.4 kg N ha ⁻¹ yr ⁻¹	
	50+ year old stand		anaerobic	9.0 kg N ha ⁻¹ yr ⁻¹	
			aerobic	1.5 kg N ha ⁻¹ yr ⁻¹	
			Twigs	- kg N ha ⁻¹ yr ⁻¹	
			Branches	.17, .05	
			Logs	1.61, 1.63	
N. Carolina, USA	Mix dec.		Soil L	-	Todd et al. 1975
			H	.08	
			0-10 cm	11.90	
			10-20 cm	2.47	
			20-40 cm	0.25	
			Total	18.16	

Table 15 Outputs - Denitrification

Location	Dominant Veg.	Age	Source	Amt (kg/ha/yr)	Reference
N. Carolina, USA	Mix dec.				Todd et al, 1975
			Twigs	.17	
			Branches	.05	
			Logs	1.61	
				1.63	
			Soil L		
			H	.08	
			0-10 cm	11.90	
			10-20 cm	2.47	
			20-40 cm	.25	
			Total	18.16	
NE USA	Mix. dec.		M.5 (0-5cm) anaerobic, NO ⁻³ (i.e. potentials)	9.02 nmoles g ⁻¹ hr ⁻¹	Limmer & Steele, 1982
Harrad forest NE USA	Pines		Forest floor + M.S.	22 kg N ha ⁻¹ yr ⁻¹	Aber et al, 1983
Trenched plots 1st year after clearcutting	Hardwoods		Forest floor + M.S.	10 kg N ha ⁻¹ yr ⁻¹	
Michigan, USA	Successional sere		Soil+forest floor	<1 (most sites) 8-50 (highest sites)	Robertson & Tiedje, 1984

Table 16 Water Chemistry Profiles

Location	Dom. Veg.	Age	Stage	Collector No.	Concn. u equiv./l							Other	Reference
					H	NO ₃	NH ₄	H ₂ PO ₄	K	Ca	Mg		
New Hampshire, USA	Abies balsamea Duration 2 years	Old	Precip.	3	83	21	13		3	9	3	Cl SO ₄ HCO ₃ Org. Anions	7 75 0 12 4 13 5 143 1 0 4 33 3 16 54 137 4 0 2 58 7 67 132 2 0 1 9 13
							6		37	36	14	Na Cl Al SO ₄ Fe HCO ₃ Mn Org Anions	
												Na Cl Al SO ₄ Fe HCO ₃ Mn Org Anions	
					15	91	8	5	16	25	15	Na Cl Al SO ₄ Fe HCO ₃ Mn Org Anions	
												Na Cl Al SO ₄ Fe HCO ₃ Mn Org Anions	
												Na Cl Al SO ₄ Fe HCO ₃ Mn Org Anions	
												Na Cl Al SO ₄ Fe HCO ₃ Mn Org Anions	
												Na Cl Al SO ₄ Fe HCO ₃ Mn Org Anions	
												Na Cl Al SO ₄ Fe HCO ₃ Mn Org Anions	
												Na Cl Al SO ₄ Fe HCO ₃ Mn Org Anions	
Findley Lake, Washington	Abies amabilis Duration ?	300	Precip.	3	22	15	3		10	26	19	Cl SO ₄ Fe HCO ₃ Mn Org Anions	Johnson, 1975
												Cl SO ₄ Fe HCO ₃ Mn Org Anions	
												Cl SO ₄ Fe HCO ₃ Mn Org Anions	
												Cl SO ₄ Fe HCO ₃ Mn Org Anions	
												Cl SO ₄ Fe HCO ₃ Mn Org Anions	
												Cl SO ₄ Fe HCO ₃ Mn Org Anions	
												Cl SO ₄ Fe HCO ₃ Mn Org Anions	
												Cl SO ₄ Fe HCO ₃ Mn Org Anions	
												Cl SO ₄ Fe HCO ₃ Mn Org Anions	
												Cl SO ₄ Fe HCO ₃ Mn Org Anions	
New Hampshire, USA	Abies balsamea Duration 2 years	111	B2 hor.	13	83	21	13		3	9	3	Cl SO ₄ HCO ₃ Org. Anions	Cronan and Schofield, 1979
							6		37	36	14	Na Cl Al SO ₄ Fe HCO ₃ Mn Org Anions	
												Na Cl Al SO ₄ Fe HCO ₃ Mn Org Anions	
					15	91	8	5	16	25	15	Na Cl Al SO ₄ Fe HCO ₃ Mn Org Anions	
												Na Cl Al SO ₄ Fe HCO ₃ Mn Org Anions	
												Na Cl Al SO ₄ Fe HCO ₃ Mn Org Anions	
												Na Cl Al SO ₄ Fe HCO ₃ Mn Org Anions	
												Na Cl Al SO ₄ Fe HCO ₃ Mn Org Anions	
												Na Cl Al SO ₄ Fe HCO ₃ Mn Org Anions	
												Na Cl Al SO ₄ Fe HCO ₃ Mn Org Anions	
Findley Lake, Washington	Abies amabilis Duration ?	300	Precip.	3	22	15	3		10	26	19	Cl SO ₄ Fe HCO ₃ Mn Org Anions	Johnson, 1975
												Cl SO ₄ Fe HCO ₃ Mn Org Anions	
												Cl SO ₄ Fe HCO ₃ Mn Org Anions	
												Cl SO ₄ Fe HCO ₃ Mn Org Anions	
												Cl SO ₄ Fe HCO ₃ Mn Org Anions	
												Cl SO ₄ Fe HCO ₃ Mn Org Anions	
												Cl SO ₄ Fe HCO ₃ Mn Org Anions	
												Cl SO ₄ Fe HCO ₃ Mn Org Anions	
												Cl SO ₄ Fe HCO ₃ Mn Org Anions	
												Cl SO ₄ Fe HCO ₃ Mn Org Anions	

Table 16 Water Chemistry Profiles

Location	Dom. Veg.	Age	Stage	Collector No.	Concen. u equiv./l							Other	Reference
					H	NO ₃	NH ₄	H ₂ PO ₄	K	Ca	Mg		
USC Res. For., S.C.	Alnus rubra, Pseudotsuga	18	Precip.	1	32	11	0.5	0.1	2	10	5	C1	17
												SiO ₂ ¹	2
												Cond. ¹	17
												HC03	5
												SiO ₂	28
												C1	34
												SiO ₂	2
												Cond.	35
												HC03	151
												SiO ₂	108
	Forest Floor leachate	14	2.5	270	1.4	0.4	69	275	117	C1	50		
										SiO ₂ ¹	62		
										Cond. ¹	77		
										HC03	77		
										SiO ₂	75		
										C1	78		
										SiO ₂ ¹	35		
										Cond. ¹	73		
										HC03	103		
										SiO ₂	64		
	B horiz. leachate	14	1.6	136	1.4	0.2	35	160	79	C1	36		
										SiO ₂ ¹	95		
										Cond. ¹	27		
										HC03	131		
										SiO ₂	59		
										C1	23		
										SiO ₂ ¹	111		
										Cond. ¹	21		
										HC03	128		
										SiO ₂	36		
	Saturated zone	10	2.0	50	1.4	0.1	24	81	35	C1	34		
										SiO ₂ ¹	3		
										Cond. ¹	0.5		
										HC03	40		
										SiO ₂	35		
										Na	1.4		
										SiO ₂	1.4		
										HC03	92		
										SiO ₂	51		
										Na	30		
	Throughfall	4-28	8	29	39	11				SiO ₂ ¹	3		
										HC03	0.5		
										SiO ₂	40		
										SiO ₂	35		
										Na	1.4		
										SiO ₂	1.4		
										HC03	92		
										SiO ₂	51		
										Na	30		
										SiO ₂ ¹	122		
	Soil leachate 30cm	1	.5	13	45	184	68			SiO ₂ ¹	189		
										HC03	125		
										SiO ₂	58		
										Na	136		
										SiO ₂ ¹	290		
										SiO ₂	50		
										Na	124		
										SiO ₂ ¹	243		
										SiO ₂ ¹	122		
										HC03	62		
SiO ₂	52												
	90cm	.4	12	11	80	34				SiO ₂ ¹	189		
										HC03	125		
										SiO ₂	58		
										Na	136		
										SiO ₂ ¹	290		
										SiO ₂	50		
										Na	124		
										SiO ₂ ¹	243		
										SiO ₂ ¹	122		
										HC03	62		
SiO ₂	52												
	150cm	.2	8	10	64	38				SiO ₂ ¹	189		
										HC03	125		
										SiO ₂	58		
										Na	136		
										SiO ₂ ¹	290		
										SiO ₂	50		
										Na	124		
										SiO ₂ ¹	243		
										SiO ₂ ¹	122		
										HC03	62		
SiO ₂	52												
	Stream	2	.2	8	16	158	91			SiO ₂ ¹	189		
										HC03	125		
										SiO ₂	58		
										Na	136		
										SiO ₂ ¹	290		
										SiO ₂	50		
										Na	124		
										SiO ₂ ¹	243		
										SiO ₂ ¹	122		
										HC03	62		
SiO ₂	52												
Northern	Aspen	3	18	3	18	3				SiO ₂ ¹	189		
										HC03	125		
										SiO ₂	58		
										Na	136		
										SiO ₂ ¹	290		
										SiO ₂	50		
										Na	124		
										SiO ₂ ¹	243		
										SiO ₂ ¹	122		
										HC03	62		
SiO ₂	52												
	Duration 2 years	Throughfall	4-28	8	29	39	11				SiO ₂ ¹	189	
											HC03	125	
											SiO ₂	58	
											Na	136	
											SiO ₂ ¹	290	
											SiO ₂	50	
											Na	124	
											SiO ₂ ¹	243	
											SiO ₂ ¹	122	
											HC03	62	
SiO ₂	52												
	Soil leachate 30cm	1	.5	13	45	184	68				SiO ₂ ¹	189	
											HC03	125	
											SiO ₂	58	
											Na	136	
											SiO ₂ ¹	290	
											SiO ₂	50	
											Na	124	
											SiO ₂ ¹	243	
											SiO ₂ ¹	122	
											HC03	62	
SiO ₂	52												
	90cm	.4	12	11	80	34				SiO ₂ ¹	189		
										HC03	125		
										SiO ₂	58		
										Na	136		
										SiO ₂ ¹	290		
										SiO ₂	50		
										Na	124		
										SiO ₂ ¹	243		
										SiO ₂ ¹	122		
										HC03	62		
SiO ₂	52												
	150cm	.2	8	10	64	38				SiO ₂ ¹	189		
										HC03	125		
										SiO ₂	58		
										Na	136		
										SiO ₂ ¹	290		
										SiO ₂	50		
										Na	124		
										SiO ₂ ¹	243		
										SiO ₂ ¹	122		
										HC03	62		
SiO ₂	52												
	Stream	2	.2	8	16	158	91				SiO ₂ ¹	189	
											HC03	125	
											SiO ₂	58	
											Na	136	
											SiO ₂ ¹	290	
											SiO ₂	50	
											Na	124	
											SiO ₂ ¹	243	
											SiO ₂ ¹	122	
											HC03	62	
SiO ₂	52												
	Stream	2	.2	8	16	158	91				SiO ₂ ¹	189	
											HC03	125	
											SiO ₂	58	
											Na	136	
											SiO ₂ ¹	290	
											SiO ₂	50	
											Na	124	
											SiO ₂ ¹	243	
											SiO ₂ ¹	122	
											HC03	62	
SiO ₂	52												
	Stream	2	.2	8	16	158	91				SiO ₂ ¹	189	
											HC03	125	
											SiO ₂	58	
											Na	136	
											SiO ₂ ¹	290	
											SiO ₂	50	
											Na	124	
											SiO ₂ ¹	243	
											SiO ₂ ¹	122	
											HC03	62	
SiO ₂	52												
	Stream	2	.2	8	16	158	91				SiO ₂ ¹	189	
											HC03	125	
											SiO ₂	58	
											Na	136	
											SiO ₂ ¹	290	
											SiO ₂	50	
											Na	124	
											SiO ₂ ¹	243	
											SiO ₂ ¹	122	
											HC03	62	
SiO ₂	52												
	Stream	2	.2	8	16	158	91				SiO ₂ ¹	189	
											HC03	125	
											SiO ₂	58	
											Na	136	
											SiO ₂ ¹	290	
											SiO ₂	50	
											Na	124	
											SiO ₂ ¹	243	
											SiO ₂ ¹	122	
											HC03	62	
SiO ₂	52												
	Stream	2	.2	8	16	158	91				SiO ₂ ¹	189	
											HC03	125	
											SiO ₂	58	
											Na	136	
											SiO ₂ ¹	290	
											SiO ₂	50	
											Na	124	
											SiO ₂ ¹	243	
											SiO ₂ ¹	122	
											HC03	62	
SiO ₂	52												
	Stream	2	.2	8	16	158	91				SiO ₂ ¹	189	
											HC03	125	
											SiO ₂	58	
											Na	136	
											SiO ₂ ¹	290	
											SiO ₂	50	
											Na	124	
											SiO ₂ ¹	243	
											SiO ₂ ¹	122	
											HC03	62	
SiO ₂	52												
	Stream	2	.2	8	16	158	91				SiO ₂ ¹	189	
											HC03	125	
											SiO ₂	58	
											Na	136	
											SiO ₂ ¹	290	
											SiO ₂	50	
											Na	124	
											SiO ₂ ¹	243	
											SiO ₂ ¹	122	
											HC03	62	
SiO ₂	52												
	Stream	2	.2	8	16	158	91				SiO ₂ ¹	189	
											HC03	125	
											SiO ₂	58	
											Na	136	
											SiO ₂ ¹	290	
											SiO ₂	50	
											Na	124	
											SiO ₂ ¹	243	
											SiO ₂ ¹	122	
											HC03	62	
SiO ₂	52												
	Stream	2	.2	8	16	158	91				SiO ₂ ¹	189	
											HC03	125	
											SiO ₂	58	
											Na	136	
											SiO ₂ ¹	290	
											SiO ₂	50	
											Na	124	
											SiO ₂ ¹	243	
											SiO ₂ ¹	122	
											HC03	62	
SiO ₂	52												
	Stream	2	.2	8	16	158	91				SiO ₂ ¹	189	
											HC03	125	
											SiO ₂	58	
											Na	136	
											SiO ₂ ¹	290	
											SiO ₂	50	
											Na	124	
											SiO ₂ ¹	243	
											SiO ₂ ¹	122	
											HC03	62	
SiO ₂	52												
	Stream	2	.2	8	16	158	91				SiO ₂ ¹	189	
											HC03	125	
											SiO ₂	58	
											Na	136	
											SiO ₂ ¹	290	
											SiO ₂	50	
											Na	124	
											SiO ₂ ¹	243	
											SiO ₂ ¹	122	
											HC03	62	
SiO ₂	52												
	Stream	2	.2	8	16	158	91				SiO ₂ ¹	189	
											HC03	125	
											SiO ₂	58	
											Na	136	
											SiO ₂ ¹	290	
											SiO ₂	50	
											Na	124	
											SiO ₂ ¹	243	
											SiO ₂ ¹	122	
											HC03	62	
SiO ₂	52												
	Stream	2	.2	8	16	158	91				SiO ₂ ¹	189	
											HC03	125	
											SiO ₂	58	
											Na	136	
											SiO ₂ ¹	290	
											SiO ₂	50	
											Na	124	
											SiO ₂ ¹	243	
											SiO ₂ ¹	122	
											HC03	62	
SiO ₂	52												
	Stream	2	.2	8	16	158	91				SiO ₂ ¹	189	
											HC03	125	
											SiO ₂	58	
											Na	136	
											SiO ₂ ¹	290	
											SiO ₂	50	
											Na	124	
											SiO ₂ ¹	243	
											SiO ₂ ¹	122	
											HC03	62	
SiO ₂	52												
	Stream	2	.2	8	16	158	91				SiO ₂ ¹	189	
											HC03	125	
											SiO ₂	58	
											Na	136	
											SiO ₂ ¹	290	
											SiO ₂	50	
											Na	124	
											SiO ₂ ¹	243	
											SiO ₂ ¹	122	
											HC03	62	
SiO ₂	52												
	Stream	2	.2	8	16	158	91				SiO ₂ ¹	189	
											HC03	125	
											SiO ₂	58	
											Na	136	
											SiO ₂ ¹	290	
											SiO ₂	50	
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											SiO ₂ ¹	122	
											HC03	62	
SiO ₂	52												
	Stream	2	.2	8	16	158	91				SiO ₂ ¹	189	
											HC03	125	
											SiO ₂	58	
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											SiO ₂ ¹	122	
											HC03	62	
SiO ₂	52												
	Stream	2	.2	8	16	158	91				SiO ₂ ¹	189	
											HC03	125	
											SiO ₂	58	
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											SiO ₂	50	
											Na	124	
											SiO ₂ ¹	243	
											SiO ₂ ¹	122	

Table 16 Water Chemistry Profiles

Location	Dom. Veg.	Age	Stage	Collector No.	Concen. u equiv./l							Reference		
					H	NO3	NH4	H2PO4	K	Ca	Mg			
Petersburg, Alaska	Picea sitchensis-Tsuga heterophylla Duration ?	Old	Precip.		2.3	Total Cations							Johnson 1975	
Northern New Mexico	Picea-Abies Duration 2 years	Precip.		3		18			3	18	3	S04	34	Graustein (unpublished Data may be revised before publication)
		Throughfall				3				72	121	31	S102 ¹	0.5
		Soil leachate 30cm	1	2.6						83	449	93	S102	6.5
		90cm	1	1.2						97	60	28	S102 ¹	339
		150cm	1	1.1						12	107	29	S102 ¹	193
Stream	1					8		28	178	129	S102 ¹	254		
											HC03	256		
											S04	123		
											Na	82		
											S102 ¹	167		

Table 16 Water Chemistry Profiles

Location	Dom. Veg.	Age	Stage	Collector No.	Concn. u equiv./l										Reference
					H	NO3	NH4	H2PO4	K	Ca	Mg	Other			
Nevada, USA	Pinus jeffreyi		Precip.		3.2	Only total		3.4	25	15	9.5	Na	18	Stark, 1973	
			Throughfall		6.3	N measured		15.5	133	93	82	Na	78		
			Forest floor		.5			3.0	115	42	33	Na	5.2		
			leachate												
			Min. Soil		16.0			5.2	151	252	107	Na	139		
			leachate 50cm												
			Stream		6.3			9.1	51	197	16	Na	113		
Oregon, USA	Pseudotsuga	450	Precip.	?		1									
			Throughfall	?		0.2									
			Litter	?		0.2									
			leachate												
			Soil 0.1 m	?		1.4									
			0.3 m	?		0.2									
			1.0 m	?		1.2									
			2.0 m	?		1.9									
			Seeps	?		0.1									
			Stream	1		0.07									
			Thompson site, Washington	Pseudotsuga	45	Precip.		12	4						
Throughfall		6.9				Tr									
Forest Floor		1.4				Tr									
A horiz.		0.7				Tr									
B horiz. (50cm)		0.8				Tr									

Table 16 Water Chemistry Profiles

200

Location	Dom. Veg.	Age	Stage	Collector No.	Concn. u equiv./l							Reference
					H	NO ₃	NH ₄	H ₂ PO ₄	K	Ca	Mg	
H.J. Andrews, Forest, Oregon	Pseudotsuga	450	Precip.	1	6.3	0.9		0.2	1	7	4	44
												7
												5
												10
												52
												11
												9
												14
												18
												28
	Duration 1-3 years		Throughfall	54	5.2	Tr		1.9	18	18	12	44
												7
												5
												10
												52
												11
												9
												14
												18
												28
			Forest Floor	2	1.5	Tr		3.0	33	58	23	44
												7
												5
												10
												52
												11
												9
												14
												18
												28
			Soil Solutions 30cm		4.1	0.4		2.2	24	372	36	44
												7
												5
												10
												52
												11
												9
												14
												18
												28
			100cm		4.4	0.1		1.5	16	398	46	44
												7
												5
												10
												52
												11
												9
												14
												18
												28
			200cm		4.3	0.5		1.8	14	324	53	44
												7
												5
												10
												52
												11
												9
												14
												18
												28
			Springs		7.0	0.4		2.7	8	159	74	44
												7
												5
												10
												52
												11
												9
												14
												18
												28
			Stream		1.2	1.4		1.7	9	160	69	44
												7
												5
												10
												52
												11
												9
												14
												18
												28
La Selva, Costa Rica	Tropical Forest	?	Precip.	30.2	Tr				Total Cations	30		44
												7
												5
												10
												52
												11
												9
												14
												18
												28
	Duration 1 month		Throughfall	2.0	10				Total Cations	130		44
												7
												5
												10
												52
												11
												9
												14
												18
												28
			A11 Hor. (15cm)	1.9	11				Total Cations			44
												7
												5
												10
												52
												11
												9
												14
												18
												28
			A12 Hor. (45cm)	0.1	11				Total Cations			44
												7
												5
												10
												52
												11
												9
												14
												18
												28
			A12 Hor. (60cm)	2.1	9				Total Cations			44
												7
												5
												10
												52
												11
												9
												14
												18
												28
												44
												7
												5
												10
												52
												11
												9
												14
												18
												28

Johnson, 1975

 u mol/l
 u S/cm

Table 17 Fire Nutrient Outputs

Location	Dom. Veg.	Age	Fire type	Output kg/ha	N	P	K	Ca	Mg	Other	Reference
Florida, USA	Pinus	0-42 yr	Periodic ground fires for 42 yr.	1270							Barnette and Hester, 1930
Minnesota, USA	Pinus banksiana	?	Forest floor burning	500-1700							Alway, 1928, cited in Ahlgren and Ahlgren, 1960
Oregon, USA	Pinus ponderosa	Old	Prescribed broadcast fire	110							Nissley et al. 1980
Arizona, USA	Pinus ponderosa	50	Thinning residue piled and burned	58							Klemmedson, 1976
California, USA	Pinus ponderosa		Prescribed broadcast fire	124							Klemmedson et al. 1962
South Carolina, USA	Pinus taeda	?	Prescribed	11-40						5 1.4-8.0	Richter et al. 1982
N. Carolina, USA	Pinus taeda	55	Prescribed Broadcast	0-12							Schoch 1983
Washington, USA	Pseudotsuga	Clearcut	Broadcast slash fire	490							Isaac and Hopkins, 1937
Washington, USA	Pseudotsuga	300	Wildfire	900							Grier, 1975
B.C., Canada	Tsuga, Pseud. Thuja	Clearcut	Broadcast Slashfire	550							Kimmins and Feller, 1976
B.C., Canada	Tsuga, Pseud. Thuja	Clearcut	Slash fire hot medium	980 500	15 10	40 20	150 80	30 10			Feller (unpublished)
Boreal	Various	?	Wildfire	320							Viro, 1974
Lake States, USA	Various		Wildfires	1800							Lovejoy, 1920, cited in Ahlgren and Ahlgren, 1960

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